EFFECT OF PLANTING MANAGEMENT FACTORS ON CANOLA PERFORMANCE IN HIGH-RESIDUE CROPPING SYSTEMS

by

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Abstract

Winter survival of canola (*Brassica napus* L.) is a challenge for producers using high-residue, no-tillage, or reduced tillage systems. In addition, as hybrid cultivars have become more available in recent years, this has brought about questions regarding best management practices to aid in mitigating winter survival challenges associated with high residue production systems. Overcoming production challenges will allow producers to diversify their no-till cropping systems with an oil seed crop having strong domestic demand. This research was undertaken to identify practices that could improve performance of canola in high-residue cropping systems. Two sets of experiments were conducted at twelve sites across Kansas from 2014 to 2016 to evaluate practices that could improve stand establishment, winter survival, and yield of winter canola. The objective of the first study conducted at 10 site years was to determine the effect of residue management, seeding density, and row spacing on stand establishment, winter survival, and yield. An innovative residue management system being developed by AGCO Corp. was compared to cooperating canola producers' no-till residue management and planting methods in wheat residue. This on-farm experiment was conducted at ten environments across Kansas. AGCO treatments were 20 or 30-in row spacing and three seeding rates for a total of six treatments. Producer treatments included their preferred row spacing, seeding rate, and residue management practices. Winter survival increased by 11% to 29% as seeding rate decreased in 20-in rows at four of the five harvested environments. At Stafford and Kingman, the lowest yielding AGCO treatment produced 3.7 to 4.2-bushel acre^{-1} more than the respective cooperator treatments. Reduced seeding rates in the AGCO system produced yields similar to or superior than the cooperator practice in all environments. Producers have been turning to planting canola in wide rows to facilitate residue management with strip tillage or planter residue management attachments. The objective of the second study conducted at three site-years was to determine the effect of seeding rate on winter survival and yield of hybrid and open-pollinated winter canola cultivars in 30-in rows. Treatments were four genotypes and five seeding rates for a total of twenty treatments. Winter survival increased with the lowest seeding rate at one of the three environments. At two of the three environments neither genotype nor seeding rate affected yield. These results indicate that seeding rates can be reduced from those typically used by canola producers in high residue, no-till or reduced tillage systems if residue can be adequately removed from the seed row. Both hybrid and open-pollinated winter canola cultivars responded similarly to seeding rate in 30-in rows in these experiments, indicating that similar seeding rates could be used for each type of cultivar. Management practices such as, narrow row spacing, reducing seeding rates, and adequately managing residue at planting may result in small improvements to establishment, winter survival and yield.

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Chapter 1 - Literature Review

Benefits of winter canola as a rotational crop in the southern Great Plains

Canola (*Brassica napus* L.) is a type of rapeseed differing from standard or industrial rapeseed because it has less than 2 percent erucic acid in the oil and less than 30 micromoles of glucosinolates per gram of oil free meal (Lin et al., 2013). Canola oil is known for its health promoting characteristics, which are low levels of saturated fatty acids along with high levels of monounsaturated fatty acids and polyunsaturated fatty acids. In the United States, canola oil is one of the most widely consumed oils, second only to soybean oil (Lin et al., 2013). The meal, a byproduct of the oil extraction process, can be utilized by livestock producers as a high-quality protein feed supplement (Assefa et al., 2014). Due to growing demand from both consumers and the livestock industry, winter canola is gaining popularity among producers as a rotational crop in the southern region of the United States (Figure 1.1).

From the late 1980's to 2007, U.S. canola production increased from 0.5 million pounds in the late 1990's to 1.5 million pounds in the past few years (Figure 1.1) with small variations in amount produced from year to year (USDA 2016a). In 2008, canola production increased by 1-million pounds, and canola acres have continued to increase with commodity demand, maintaining small year-to-year fluctuations. Canola acres increased from 2013 to 2015 by 32%, however acres are projected to decrease slightly in 2016 (USDA 2016 b, USDA 2016c).

Historically, canola has been grown in Canada as a spring variety, however the expansion of spring canola into the southern Great Plains is limited by high temperature stress during flowering and seed development stages (Rife et al., 2003; Raymer et al., 1990). Growing conditions in the southern Great Plains can be characterized by hot summer days with high sunlight intensity, a summer rainfall pattern, and cold, dry winters (Farahani et al., 1998). Winter hardy and freeze tolerance mechanisms have been developed within cultivars to withstand winters in the southern Great Plains, making winter canola a well suited rotational crop where winter wheat (*Triticum aestivum* L.) is grown. Low temperature acclimation is among the important winter survival mechanisms breeders have established in winter canola (Rife et al., 2003). Cooperative research efforts of both public and private breeders have produced winter-tolerant cultivars found on the market today (Bushong et al., 2012).

Due to the nature of growing conditions in the southern Great Plains, until recently producers historically have grown continuous winter annuals, such as winter wheat in no-till and conventional tillage cropping systems on rainfed cropland (Hansen et al., 2012). No-till is a management practice many producers have adopted to combat challenges in this environment such as soil moisture conservation. However, when coupled with limited crop rotation, the result has been a decline in the quality of winter wheat due to increased weed and insect populations (Bushong et al., 2012). Producers must implement management practices such as crop rotations that effectively break weed and insect cycles as well as conserve soil moisture to minimizing risk of crop failure. Considering these factors, winter canola can be well suited for southern Great Plains agriculture and shows great promise for expanding acreage (Holman et al., 2011).

Diverse rotations containing an array of crop types are foundational for the success of no-till cropping systems (Holman et al., 2011). Including winter canola in a rotation with winter wheat greatly enhances weed management options (Bushong et al., 2012). Development of transgenic canola, particularly glyphosate-resistant cultivars, has broadened approved herbicides for winter canola, improving weed control (Johnson et al., 2003). Difficult to control winter annual grasses, particularly Italian rye grass (*Lolium perenne* L.) and feral rye (*Lolium multiflorum* L.), have invaded fields located in the southern Great Plains that have traditionally been used to produce continuous winter wheat (Bushong et al., 2012; Peeper et al., 2000). Weeds can decrease the value of a wheat crop through direct competition by reducing yields and by decreasing quality due to foreign material in the grain, which results in price reductions (Justice et al., 1994; Bushong et al., 2012). Bushong et al. (2012) reported wheat yields in a canola rotation system being as much as 22% greater than yields in continuous-wheat systems. Due to weed pressure and the difficulties associated with growing summer crops in the southern Great Plains, interest in growing winter canola as a rotational crop with winter wheat in no-till systems has increased in recent years (Lofton et al., 2010; Bushong et al., 2012, Wysocki et al., 2009).

Production practices to mitigate winter survival effects

Canola can be a particularly challenging crop when it comes to winter survival in no-till cropping systems (Young et al., 2013). An important decision in terms of agronomic practices for canola in no-till production includes the management of residue left from the previous year's crop. The success of direct seeding winter canola into wheat residue has received criticism in recent years due to extreme winter stand loss (Holman et al., 2011). If seed to soil contact is poor, the roots may not penetrate the soil surface and simply develop underneath the residue. Placing the seed too shallow and not penetrating the soil surface will result in a shallow rooted canola plant, and lengthening of the crown above the soil surface, making the plant susceptible to winter kill. Crown height is an important factor for winter survival, the closer the crown is to the soil surface, the chances for adequate winter survival increase greatly (Holman et al., 2011, Rybka, 1993). To mitigate these effects, adequate seed to soil contact is important when directly seeding into undisturbed heavy residue (Holman et al., 2011, Wysocki et al., 2009). This is largely an issue that must be resolved at planting. Moving residue and surface soil away from the row can mitigate the negative effects of residue coverage (Wysocki et al., 2009). There are various ways to mitigate the effect of residue through either removal by burning or tillage, or by managing it with planting equipment. Although burning and tillage are both means of removing heavy residue and do a nice job of preparing the seed bed, these methods are not optimal due to soil moisture loss. Evaporation is responsible for the greatest amount of water loss in dryland cropping systems and management practices such as no-till have been adopted to reduce evaporative losses (Hansen et al. 2012).

Residue is critical for moisture-limited dryland production systems; therefore, it is important to evaluate ways to manage it in terms of cleaning the seed row. An optimal management system for canola depends on the complex interaction between plants, soil, environmental factors, and agronomic practices (Kutcher et al., 2013). Among the decisions that growers must make in terms of agronomic practices are choice of seeding rate, spacing between rows, and genetics, which may have large effects on seed yield and oil quality (Kutcher et al., 2013).

Row spacing

Many producers in the southern Great Plains are equipped to plant small grains such as wheat. The transition from other small grains to canola has been relatively easy because common production equipment can be used (Johnson et al., 2003). Conventional grain drills and air seeders used for seeding small grains can also be used for seeding canola. As canola is becoming a larger part of crop rotations and producers are updating seeding equipment it may be beneficial consider equipment and methods that work best for seeding winter canola. One of those considerations is linked to planting equipment and the ideal row width to achieve optimal yields and crop quality. Published studies of the effect of row width on winter canola plant density and yield in no-till production systems are few and the results variable (Kutcher et al., 2013). Many of the studies have been conducted with spring canola in areas of high rainfall (Wysocki et al., 2009). These studies have generally examined row spacings commonly used for planting cereals, but few have looked at wider spacings in terms of soil and residue management (Wysocki et al., 2009).

A method that has been tried by innovative producers in the Pacific Northwest is to plant canola into cultivated fallow or chem-fallow using wider row spacing than used for winter wheat (Wysocki et al., 2009). This allows wide shovel openers to move dry, surface soil and residue to the areas between the rows and creates a seed row that is shallow to moist soil, allowing the seed to be placed relatively shallow with a minimum of soil and residue cover (Wysocki et al., 2009).

When comparing, and contrasting wide versus narrow row spacing, there are benefits and risks associated with both. Wider rows have the potential to better prepare the seed row, allowing for increased stand establishment (Kutcher et al., 2013, Wysocki et al., 2009). However, wider rows may have an adverse effect on yield, and narrower row width can provide quicker canopy closure, reducing weed competition and lessening wind shattering before harvest (Wysocki et al., 2009). In contrast, narrower rows decrease time to canopy closure, therefore increasing light interception, however may also result in cooler soil temperatures (Bradley et al., 2006). The adoption of narrow row spacing (row widths less than 30-in) in other crops such as soybeans and corn has primarily been driven by the potential for greater yields in narrow-row compared to wide-row systems (Bradley et al., 2006). Morrison et al. (1990) reported greater yields from 6- than from 12-in row width in one of three site years for summer rape planted with conventional tillage in Canada. Greater yields at narrower rather than wider row width was thought to be partially due to less interplant competition that resulted in a greater number of pods per plant and seeds per pod. Kutcher et al. (2013) reported spring canola plant density decreasing with wider row width in a no-tillage production system. They reported that plant density dropped from 453,248 plants acre^{-1} at the 9-in width to 335, 889 plants acre^{-1} at the 24-in row width. Young et al. (2013) observed greater fall establishment of 135,575 plants acre^{-1} in dry soil with drill modifications that added shovels in front of the seed openers for residue management versus no shovels at 106, 560 plants acre^{-1}. Although increased plant densities and more uniform plant distribution were achieved with the shovel openers, these did not affect yield or winter survival, which was 75% across years and shovel treatments. Kutcher at al. (2013) observed a decrease in yield with wider row width, from 2143 lb acre^{-1} at the 9-in row width to 1904 lb acre^{-1} at the 24-in row width. In northeastern North Dakota (US), where average yearly rainfall is 19.5 inches, Johnson et al. (2003) observed spring canola producing nearly identical yields in conventional tillage from stands grown at 6- and 12-in row width. The same authors noted that yield responses were consistent across five diverse environments regardless of precipitation limitations (Johnson et al., 2003). Work done by Wysocki et al. (2009) in Oregon (US) found that greatest yields were obtained by 6- or 12-in row spacing when compared to 24- and 30-in in winter canola, but the 24-in treatment was not significantly different for the second year of the experiment. They concluded that if stand establishment can only be achieved with wider rows, then 24-in is preferred over 30-in row spacing. Yield improvements approaching 36% have been observed in narrow- compared to wide-rows, making row spacing an important consideration for canola production (Wysocki et al., 2009).

Seeding rate

Although much research has been done on the effects of optimal seeding rates with spring canola, little research has been conducted for winter canola on stand establishment and winter survival (Young et al., 2013). Plant density response to seeding rate is one important factor. Kutcher et al. (2013) found that plant densities in no-till spring canola, increased linearly with increasing seeding rate in 9- and 24-in rows. In their work, plant density increased from 190,080 plants acre^{-1} at a seeding rate of 2.9 lb acre^{-1} to 430,846 plants acre^{-1} at a seeding rate of 8.5 lb acre^{-1}. Young et al. (2013) found that greatest fall densities for winter canola were established with rates of 6 and 8 lb acre^{-1} when compared to lower rates of 2 and 4 lb acre^{-1} in 28-in rows. For all growing seasons in this study, the greatest spring plant densities were associated with the 8-lb acre^{-1} seeding rate compared to the 4-lb acre^{-1} seeding rate. Young at al. (2013) also found that winter survival ranged from 56 to 83%, with the highest percentage survival at the 2-lb acre^{-1} rate for one site year, with differences not being as large in subsequent years. Across studies fall establishment increased in response to seeding rate increases.

Kutcher el al. (2013) determined that with the range of seeding rates evaluated in their study, no effect on yield was observed regardless of plant density differences. Similarly, Christensen et al. (1984) did not find significant yield differences between seeding rates of 1.3 and 2.5 lb' acre^{-1} in row spacing ranging from 3- to 9-in for summer rapeseed in northwestern Alberta. Christensen et al. (1984) proposed that the reason such high seeding rates have historically been proposed for summer rapeseed is to ensure a large enough plant density at early growth stages to be competitive with weeds. The advantage of high inter-species competition may be offset, by a higher intra-species competition, potentially resulting in similar yield loss (Christensen et al., 1984). Young et al. (2013) found that yield was almost 20% greater at the 4- compared with the 8-lb acre^{-1} rate, even though greatest fall and spring densities were achieved at the 8-lb acre^{-1} rate, indicating that intraspecific competition reduced winter canola yield. These set of studies indicate that yield does not show a large response to seeding rate changes.

Cultivar

Rapeseed was first grown extensively in Canada in the early 1940's for industrial purposes (Brandt et al., 2007, Lin et al., 2013). The crop proved to be well adapted to areas of Canada shifting interest to produce canola for other purposes. Early plant breeding efforts focused on improving the quality of the oil for human and livestock consumption. These genetic modifications to the quality of the rapeseed led to the development of what is known today as canola, based on cultivars with low concentrations of uric acid and glucosinolates (Brandt et al., 2007). In early years, yield improvements were modest, in addition many of the current production and management practices that producers use today were developed at that time. More recently, breeders have focused on improving agronomic traits in new cultivars, and with that there has been a substantial yield improvement. Brandt et al. (2007) suggests that revisions to management practices may be needed to realize the true value of the improved genetics.

A successful winter canola crop is achieved through the multifaceted interaction of genetics, management, and environment. One of the major differences between cultivars on the market today is open-pollinated versus hybrid genotypes. One of the characteristics that separate the two is seed size, with hybrid seed tending to be larger (60,000 to 90,000 seeds/lb) than open pollinated seed (100,000 to 125,000 seeds/pound) (Stamm et al. 2012). Brandt et al. (2007) suggests that yield advantages of 40 to 72% have been achieved with hybrid versus open pollinated cultivars. Assefa at al. (2013) looked at varieties based on differences in agronomic factors such as yield potential, winter survival, hybrid versus open pollinated, and crown height, to name a few. The same authors found that cultivar influenced yield, crown height, and winter survival. Crown height can be important when considering plant characteristics that contribute to increased winter survival because elevated crown heights can be associated with greater winter stand loss (Holman et al., 2011). Although Assefa et al. (2014) observed that cultivars differed in crown height, it did not appear that it was correlated with hybrids versus open-pollinated cultivars. On the other hand, winter survival was 7% less for the hybrid than for the lowest ranking open pollinated varieties. Hybrids had the yield advantage for the earliest planting dates in nearly all years of the study. This could be attributed to hybrid vigor, which can lead to more aggressive vegetative growth. Early work by McVetty (1995) states that high parent heterosis for seed yield in hybrid Brassicas is frequently encountered. McVetty (1995) also suggests that in many cases this increase in yield is due to an increase in the number of pods per plant while all other yield components display compensating interactions.

In Canada, Kutcher et al. (2013) compared the main effects of open pollinated and hybrid spring canola varieties, observing a plant density of 372,446 plants acre^{-1} for the open pollinated cultivar to 425,074 plants acre^{-1} for the hybrid cultivar. However, these population differences did not translate to differences in yield between the open pollinated and hybrid spring cultivars. Assefa et al. (2014) also looked at the interaction effects of planting date and cultivar on winter survival and found no significant interaction, however, planting date impacted winter survival in almost all years. Although, the results were variable across the three years. The same authors concluded that selection of high performing cultivars for a given environment and planting at the right time for optimal winter survival along with other factors will maximize the yield potential of canola. These studies collectively indicate that there are some differences between hybrid and open-pollinated genotypes, however in general they did not translate to large yield differences.

Research Question and Justification

Winter survival of canola (*Brassica napus* L.) is a major challenge for producers using high-residue, no-tillage systems. The direct seeding of winter canola into un-disturbed residue has proven to be a challenge due to its effects on winter survival and ultimately yield. Perfecting no-till planting methods for crops that facilitate diversification of wheat-dominated rotations is important to the success of these rotations. Overcoming this challenge will allow producers to diversify their no-till cropping systems with an oil seed having strong domestic demand.

Production practices and cultivar selection can play a large role in the successful production of winter canola. Researchers suggest that planting canola in wide rows can have a negative impact on yield (Wysocki et al., 2009). Some also suggest that winter survival increases with decreased seeding rates (Young et al., 2013). Early researchers of hybrid canola believed that a yield bump could be achieved with hybrid cultivars (McVetty, 1995). The goal of this research was to evaluate procedures to manage residue, ideal row spacing, optimal seeding rates, and evaluate hybrid and open pollinated cultivars. The overall goal of these research experiments is to discover management practices that can help maximize stand establishment, winter survival and yield of winter canola.

Specific research objectives were to:

1. Compare AGCO's innovative residue management system to canola producers existing no-till residue management system.

   AGCO's residue management systems could allow planting canola into heavy residue, resulting in improved stands establishment, winter survival, and yield.

2. Determine the effect of row spacing and seeding density on stand establishment, winter survival, and yield.

   As row spacing increases, within-row plant spacing decreases, increasing plant-to-plant competition and potentially reducing winter survival and yield.

3. Determine optimum seeding rates for open pollinated and hybrid genotypes in 30-in row spacing.

   Hybrids should emerge more quickly resulting in increased fall growth, better winter survival, improved spring stands, and ultimately yield; therefore, to maximize yields optimum seeding rates for open pollinated and hybrid cultivars in 30-in rows will be different.

References

Assefa, Y., K. Roozeboom, M. Stamm, 2014. Winter canola yield and survival as a function of environment, genetics, and management. Crop Sci. 54:2303-2313.

Bushong, J.A., A.P. Griffith, T.F. Peeper, and F.M. Epplin. 2012. Continuous winter wheat versus a winter canola winter wheat rotation. Agron. J. 104:324-330.

Bradley, K.W. 2006. A review of the effects of row spacing on weed management in corn and soybean. [Online] Crop Manage. Doi:10.1094/CM-2006-0227-02-RV.

Brandt, S.A., S.S. Malhi, D. Ulrich, G.P. Lafond, H.R. Kutcher, A.M. Johnson. 2007. Seeding rate, fertilizer level, and disease management effects on hybrid versus open pollinated canola. Can. J. Plant Sci. 87:255-266.

Christensen, J.V., J.C. Drable. 1984. Effect of row spacing and seeding rate on rapeseed yield in northwest Alberta. Can. J. Sci. 64:1011-1013.

Farahani, H.J., G.A. Peterson, D.G. Westfall, L.A. Sherrod, and L.R. Ahuja. 1998. Soil water storage in dryland cropping systems: The significance of cropping intensification. Soil Sci. Soc. Am. J. 62:984-991.

Hansen, N., B. Allen, R. Baumhardt, D. Lyon. 2012. Research achievements and adoption of no-till, dryland cropping in the semi-arid U.S. Great Plains. Field Crops Research. 196-203.

Holman, J., S. Maxwell, M. Stamm, K. Martin. 2011. Effects of planting date and tillage on winter canola. Online. Crop Manage. doi:10.1094/CM-2011-0324-01-RS.

Johnson, B.L., and B.K. Hanson. 2003. Row-spacing interactions on spring canola performance in the northern Great Plains. Agron. J. 95:703-708.

Justice, G.G., T.F. Peeper, J.B. Solie, and F.M. Epplin. 1994. Net returns from Italian ryegrass (*Lolium multifl orum*) control in winter wheat (*Triticum aestivum*). Weed Tech. 8:317–323.

Kutcher, H.R., T.K. Turkington, G.W. Clayton, and K.N. Harker. 2013. Response of herbicide-tolerant canola (*Brassica napus* L.) cultivars to four row spacings and three seeding rates in a no-till production system. Can. J. Plant Sci. 93:1229-1236.

Lin, L., H. Allemekinders, A. Dansby, L. Campbell, S. Durance-Tod, A. Berger, and P. J. Jones. 2013. Evidence of health benefits of canola oil. Nutrition Reviews, 71(6), 370–385. http://doi.org/10.1111/nure.12033

Lofton, J., C.B. Godsey, and H. Zhang. 2010. Determining aluminum tolerance and critical soil pH for winter canola production for acidic soils in temperate regions. Agron. J. 102:327–332. doi:10.2134/agronj2009.0252.

McVetty, P.B.E. 1995. Review of performance and seed production of hybrid brassicas. Dept. Plant Sci. Univ. Manitoba, Winnipeg, MB, Canada.

Morrison, M.J., P.B.E. McVetty, and R. Scarth. 1990. Effect of row spacing and seeding rates on summer rape in southern Manitoba. Can. J. Plant Sci. 70:127-137.

Peeper, T.F., J.P. Kelley, L. Edwards, and J. Krenzer E.G. 2000. Italian ryegrass control in Oklahoma wheat for fall 2000. PT 2000-23. Oklahoma Coop. Ext. Serv., Stillwater.

Raymer, P.L., D.L. Auld, and K.A. Mahler. 1990. Agronomy of canola in the united states. Springer U.S. Doi: 10.1007/978-1-4615-3912-4_3.

Rife, C.L., and H. Zeinali. 2003. Cold tolerance in oil seed rape over varying acclimation durations. Crop Sci. 43:96-100.

Rybka, Z. 1993. Morphology of crown the overwintering organ of winter wheat seedling. ACTA Soc. Bot. Pol. Vol. 62, No. 3-4:127-129.

Stamm, M., J. Bushong., H. Sanders., M. Boyles. 2012. Great Plains canola production handbook. Kansas State University [Online]. http://www.bookstore.ksre.ksu.edu/pubs/mf2734.pdf.

United States Department of Agriculture Economic Research Service. 2016a. Canola. Kansas office of USDA's NASS. [Online]. http://www.ers.usda.gov/topics/crops/soybeans-oil-crops/canola.aspx

United States Department of Agriculture National Agriculture Statistics Service. 2016b. Prospective plantings. Kansas office of USDA's NASS. [Online]. http://usda.mannlib.cornell.edu/usda/current/ProsPlan/ProsPlan-03-31-2016.pdf

United States Department of Agriculture National Agriculture Statistics Service. 2016c. Crop production summary. Kansas office of USDA's NASS. [Online]. http://www.usda.gov/nass/PUBS/TODAYRPT/cropan16.pdf.

Wysocki, D., N. Sirovatka. 2009. Growing Canola on Wide Row Spacing. Oregon Agric. Exp. Station Spec Rep 879:50-55.

Young, F.L., W.L. Whaley, R. Pan, D. Roe, J.R. Alldredge. 2013. Introducing Winter Canola to the Winter Wheat-Fallow Region of the Pacific Northwest. Crop Manage. Dio:10.2134/CM-2013-0023-RS.

Figure

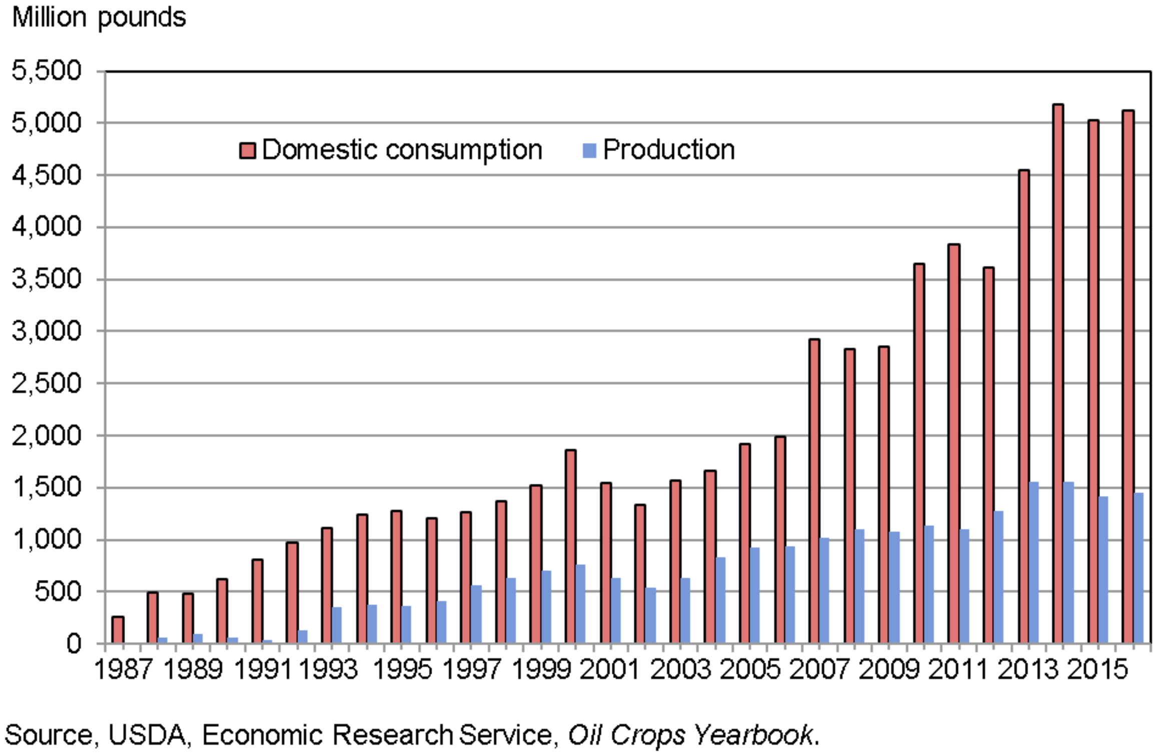


Figure 1.1. U.S. canola oil production and demand from 1987 to 2015.

Chapter 2 - The Effect of Residue Management, Row Spacing, and Seeding Rate on Winter Canola Establishment and Survival

Abstract

Winter survival of canola (*Brassica napus* L.) is a challenge for producers using high-residue, no-tillage, or reduced tillage systems. If seed to soil contact is poor, the roots may not penetrate the soil surface and simply develop underneath the residue. Placing the seed too shallow and not penetrating the soil surface will result in a shallow rooted canola plant, and lengthening of the crown above the soil surface, making the plant susceptible to winter kill. The objective of this study was to determine the effect of residue management, seeding density, and row spacing on stand establishment, winter survival, and yield. An innovative residue management system being developed by AGCO Corp. was compared to five cooperating canola producers' no-till residue management and planting methods in wheat residue. This on-farm experiment was conducted in 2014-15 and 2015-16 at ten environments across Kansas. AGCO treatments were 20 or 30-inch row spacing and three seeding rates for a total of six treatments. Producer treatments included their preferred row spacing, seeding rate, and residue management practices. Due to winter stand loss, one of the six experiments was harvested for yield in 2015. All four experiments in the 2015-16 growing season were harvested for yield. In most cases, cooperator practices produced the greatest fall establishment and spring densities at each environment. Winter survival increased by 11% to 29% as seeding rate decreased in 20-in rows at four of the five environments. At Stafford and Kingman, the lowest yielding AGCO treatment produced 3.7 to 4.2-bushel acre^{-1} more than the respective cooperator treatments. In general, fall plant density followed seeding rate differences, regardless of row spacing or planting system. Winter survival improved as seeding rates decreased within the AGCO system in 20-in rows, potentially a result of wider intra-row

plant spacing that is achieved with narrower rows. Within the AGCO treatments 20-in rows were favorable for fall establishment, spring stands, winter survival and yield when compared to 30-in rows. Reduced seeding rates in the AGCO system produced yields similar or superior to cooperator practice in all environments. These results indicate that seeding rates can be reduced from those typically used by canola producers in high residue, no-till or reduced tillage systems if residue can be adequately removed from the seed row.

Introduction

Canola can be a particularly challenging crop when it comes establishing a stand that will undergo successful winter survival in no-till cropping systems (Young et al., 2013). An important decision in terms of agronomic practices for canola in no-till production includes the management of residue left from the previous year's crop. The success of direct seeding winter canola into wheat residue has received criticism in recent years due to extreme winter stand loss (Holman et al., 2011). If seed to soil contact is poor, the roots may not penetrate the soil surface and simply develop underneath the residue. Placing the seed too shallow and not penetrating the soil surface will result in a shallow rooted canola plant, and lengthening of the crown above the soil surface, making the plant susceptible to winter kill (Holman et al., 2011). Crown height is an important factor for winter survival, the closer the crown is to the soil surface, the chances for adequate winter survival increase greatly (Holman et al., 2011). To mitigate these effects, adequate seed to soil contact is important, when directly seeding into undisturbed heavy residue (Holman et al., 2011).

There are various ways to mitigate the effect of residue through either removal by burning or tillage, or by managing it with planting equipment. Although burning and tillage are both means of removing heavy residue and do a nice job of preparing the seed bed, these methods are not optimal due to soil moisture loss. Evaporation is responsible for the greatest amount of water loss in dryland cropping systems and management practices such as no-till have been adopted to reduce evaporative losses (Hansen et al. 2012). Research suggests that residue can be very beneficial to southern Great Plains crop production, therefore it is important to evaluate ways to manage it in terms of cleaning the seed row. An optimal management system for canola depends on the complex interaction between plants, soil, environmental factors, and agronomic practices (Kutcher et al., 2013). Among the decisions that growers must make in terms of agronomic practices are choice of seeding rate, spacing between rows, and genetics, which may have large effects on seed yield and oil quality (Kutcher et al., 2013).

One of those considerations is linked to planting equipment and the ideal row width to achieve optimal yields and crop quality. Published studies of the effect of row width on winter canola plant density and yield in no-till production systems are few and the results variable (Kutcher et al., 2013). These studies have generally examined row spacing commonly used for planting cereals, but few have looked at wider spacing in terms of soil and residue management (Wysocki et al., 2009). Potential benefits to using row crop planting equipment with wider row width for no-till canola production include: better residue management over the row, less soil disturbance, and more precise seed placement (Kutcher et al., 2013).

When comparing, and contrasting wide versus narrow row spacing, there are benefits and risks associated with both. Wider rows have the potential to better prepare the seed row, allowing for increased stand establishment (Wysocki et al., 2009). However, Kutcher et al. (2013) reported spring canola plant density decreased with wider row width in a no-tillage production system. In contrast, wider rows may have an adverse effect on yield, and narrower row width can provide quicker canopy closure, reducing weed competition and lessening wind shattering before harvest

(Wysocki et al., 2009). Greater yields at narrower rather than wider row width was thought to be partially due to less interplant competition that resulted in a greater number of pods per plant and seeds per pod. The adoption of narrow row spacing (rows less than 30-in in width) in other crops such as soybeans and corn has primarily been driven by the potential for greater yields in narrow- compared to wide rows production systems (Bradley et al., 2006).

Although much research has been done on the effects of optimal seeding rates with spring canola, little research has been conducted for winter canola on stand establishment and winter survival (Young et al., 2013). Young et al. (2013) found that greatest fall densities for winter canola were established with rates of 6 and 8 lb acre^{-1} when compared to lower rates of 2 and 4 lb acre^{-1} in 28-in rows. For all growing seasons in this study the greatest spring plant densities were with the 8-lb acre^{-1} seeding rate compared to the 4-lb acre^{-1} seeding rate. In contrast, Young at al. (2013) also found that winter survival ranged from 56 to 83%, with the highest percentage survival at the 2-lb acre^{-1} rate for one site year, with differences not being as large in subsequent years. In earlier research, high seeding rates were proposed for summer Rapeseed too ensure a large enough plant density at early growth stages to be competitive with weeds (Christensen et al., 1984). More recent research suggests that backing off commonly used seeding rates could have production benefits and with the introduction of herbicide tolerant cultivars this could be feasible. Young et al. (2013) found that yield was almost 20% greater at the 4-lb acre^{-1} compared with the 8-lb acre^{-1} rate, even though greatest fall and spring densities were achieved at the 8-lb acre^{-1} rate, indicating that intraspecific competition reduced winter canola yield. This is also recorded in literature with other crops capable of compensatory abilities such as soybeans, which allows yields to be maintained across changing plant densities (Epler et al., 2008).

Research Question and Justification

Growing interest in winter canola (*Brassica napus* L.) from producers throughout the southern Great Plains has brought about questions regarding best management practices. Winter survival of canola (*Brassica napus* L.) is a major challenge for producers using high-residue no-tillage systems. The direct seeding of winter canola into un-disturbed residue has proven to be problematic due to its effects on winter survival and ultimately yield. Perfecting no-till planting methods for crops that facilitate diversification of wheat-dominated rotations is important to the success of these rotations. Overcoming this challenge will allow producers to diversify their no-till cropping systems with an oil-seed crop having strong domestic demand. Production practices and cultivar selections can play a large role in the successful production of winter canola. Researcher suggests that planting canola in wide rows can have a negative impact on yield (Wysocki et al., 2009). Some also suggest that winter survival increases with decreased seeding rates (Young et al., 2013). Growers want to seed at the optimum seeding rates for greatest production and are concerned about the influence of row spacing on canola performance (Johnson et al., 2003). The objective of this research study was to compare AGCO's innovative residue management system to canola producers existing no-till residue management system. Our hypothesis was that AGCO's residue management systems could allow planting canola into heavy residue, resulting in improved winter survival. The second objective was to determine the effect of row spacing and seeding density on stand establishment, winter survival, and yield. With this objective in mind our hypothesis was that, as row spacing increases, within-row plant spacing decreases, increasing plant-to-plant competition and potentially reducing winter survival and yield.

Materials and Methods

Ten field experiments were conducted over two canola growing seasons in 2014-15 and 2015-16 at cooperator fields (Table 2.2) in Kansas to compare the AGCO planting system with standard cooperator practice (Table 2.1). These environments were selected based on cooperator interest in no-till or reduced tillage residue management methods, as well as other management factors such as planting equipment, row spacing and seeding rates. Experiments in 2014-15 were planted into either corn or wheat residue and 2015-16 experiments were planted into wheat residue.

An innovative residue management planting system being developed by AGCO (AGCO Corp., Hesston, KS) was compared to cooperating canola producers' existing no-till residue management methods. The AGCO residue management system consisted of additional residue managers placed between the double-disc furrow openers and the seed firmer to maximize the movement of residue out of the seed row in addition to anchoring the residue between rows with a small amount of soil. AGCO treatments included novel residue management in both 20- and 30-in row spacings, each with 100,000, 150,000, and 200,000 seeds acre^{-1} for a total of six AGCO treatments. These treatments were compared to each cooperator's preferred planting method (Table 2.1) for no-till or reduced tillage systems. Cooperator seeding rates ranged from 191,000 to 684,000 seeds acre^{-1} and row spacings ranged from 10- to 30-in, depending on cooperator preference and farming operation. Some producers were equipped with drills to plant small grains such as wheat, and others utilized their row crop planters. Cooperators controlled weeds and insects as needed per locally appropriate winter canola management recommendations. Fertilizer were applied by the cooperators to the entire experiment and reflected their typical fertility management practices (Table 2.1). The one exception was at Stafford where the fall N and S applications to the AGCO treatments was accomplished via streaming of liquid product to produce the same rates as applied by the cooperator in his strip tillage operation. As a result, the rates of P_2O_5 and K_2O applied in cooperator passes were not applied in the AGCO plots at the Stafford location.

Characterization of winter canola response to residue management, seeding rate, and row spacing included quantifying fall plant density, spring plant density, pre-dormancy plant stage, winter survival, bloom progression, and yield. Fall plant density was quantified by counting the number of plants in four, 1-m lengths of row in each plot at the two to five-leaf stage in fall 2014 and four, 3-m lengths of row in fall 2015. Plant stages were established by counting the number of leaves 4 to 8 weeks after planting, soon before winter dormancy. Spring density was quantified in March by counting plants in the same four, 1-m or 3-m lengths of row that had been counted in the fall. Winter survival was calculated by dividing spring plants per acre by fall plants per acre and multiplying by 100, obtaining the percentage of plants remaining after dormancy. Bloom progression was quantified by visually estimating the percentage of plants that were blooming in each plot on the same date approximately two months before harvest.

For all environments, each plot was swathed and combined individually with commercial cooperator equipment. Producer practice at all environments was swathing when 40 to 60% seed color change could be observed on the plant main raceme. Fields were swathed with a 25 or 30-ft sickle bar swather equipped with a windrower draper header, windrowed and left to dry for 6 to 9 days before combining (Table 2.1), depending on weather and producer preference. Seed color change indicating optimal swathing time at Andale was reached June 21, 2015 and in 2016, between May 29th and June 4th depending on environment (Table 2.1).

Yield was determined by obtaining the weight of the harvested seed from one 25- or 30-ft wide harvest pass from each plot, when grain reached 8 to 10% moisture. Grain weight was obtained by weighing harvested seed from each plot with a weigh wagon or grain cart or by obtaining total grain weight for each plot from calibrated combine yield monitors (Table 2.1) using the “Load” function. Samples were collected from each plot, and a 5-g subsample was sent to the Brassica Breeding and Research program at the University of Idaho (Moscow, ID) for near-infrared spectroscopy (NIRS) oil content estimation (Jiang et al., 2005). Plot dimensions were roughly 30- by 600-ft, however exact plot length and cooperator plot width varied by environment to accommodate a variety of cooperator planting equipment.

The experimental design was a randomized split block design with planting equipment as a split in each replicate for a total of seven treatments and three replicates. Row spacing and seeding rate were fixed effects, replication, and subsample (fall establishment and spring stands) were random effects. Statistical analysis was completed using the PROC GLIMMIX procedure, $\alpha = 0.1$, in SAS 9.4 (SAS Institute, 2014) statistical analysis software. Analysis of all seven treatments was completed by including producer practice to allow comparisons with AGCO treatments. A separate analysis of the six AGCO treatments excluding producer practice allowed testing the main effects and interaction of seeding rates and row spacing. Andale 2015 raw yield data were adjusted using a spatial covariate (Yang and Juskiw, 2011) to correct for an underlying north-south trend. Yields were plotted against fall establishment, spring stands, and winter survival to determine if relationships existed between measures of plant density or survival and yield. A Pearson correlation analysis was performed to determine the strength of correlations between variables, where yields were standardized as a percent of maximum yield within each experiment. Correlation was performed for each environment separately and across the five environments.

Results

Pre-dormancy leaf number

The number of leaves present as the plants entering dormancy provides one measure of how fall plant growth may have responded to treatment. Because fall growth is important for winter survival, plants should have a minimum of 3 to 4 leaves going into winter dormancy (Stamm et al., 2012). At Andale, the AGCO 20-in row spacing at 150,000 and 200,000 seeds acre^{-1} and the 30-in row spacing at 100,000 and 200,000 seeds acre^{-1} treatments were all similar at 4.9 to 5.0 leaves per plant (Table 2.3). Plants in the cooperator practice treatment averaged 4.0 leaves. Plant stage ranged from 3.4 to 4.7 leaves per plant at the Kingman environment. Leaf number did not consistently differ in response to row spacing in AGCO treatments. There were significant differences when comparing 100,000 and 150,000 seeds acre^{-1} seeding rates. In general, at the Conway Springs, Stafford and Kiowa environment leaf number increased with seeding rate 100,000 to 150,000 seeds acre^{-1}, but did not increase with seeding rate from 150,000 to 200,000 seeds acre^{-1}. Within the AGCO treatments, seeding rate affected leaf number at all environments, but the response was not consistent across environments. Leaf number was greatest in 20-in rows at two of the five environments. At one of the environments all AGCO treatments had the greatest leaf numbers when compared to producer treatment.

Fall plant establishment

Fall plant establishment differed in response to residue management/planting equipment, row spacing and seeding rate in all environments (Table 2.4). Fall plant density of the AGCO treatments at the Andale environment (2014) were significantly greater than targeted seeding rates, and all were greater than cooperator practice. Cooperator practice at Stafford was similar to AGCO 150,000 seed acre^{-1} in 20-in rows. At all other environments cooperator practice produced the greatest establishment, however cooperator seeding rates typically were substantially greater then AGCO seeding rates. At all environments in fall 2015, plant density increased with increasing seeding rates for both 20-in and 30-in row spacing, however in general, plant density was less than targeted seeding rates. When considering seeding rates within AGCO treatments, at four of five environments, plant density increased as seeding rates increased for the AGCO seeding rate treatments. Comparing AGCO row spacing treatments, plant density significantly increased in response to 20-in row spacing at three of five environments compared to 30-in row spacing. In general, fall plant establishment increased with increasing seeding rates for both 20 and 30-in rows. In general, stands increased with increasing seeding rate and at three of the five environments establishment was greatest in 20-in rows. Cooperator practice produced greatest fall establishment at three of the five environments. It is important to point out that cooperator seeding rates at these environments were notably greater than AGCO seeding rates.

Spring plant density

At three of the five environments cooperator treatments produced the greatest spring plant stands (Table 2.5), however producer practice seeding rates were greater than AGCO seeding rate treatments at all environments except for Andale (Table 2.2). At the remaining two environments, one of the AGCO 20-in row spacing treatments achieved the greatest densities. Plant stands at Andale in spring 2015 were notably less when compared to fall densities prior to winter. At this environment, fall establishment increased with increasing seeding rates, but spring stands decreased with increasing seeding rates ($r = -0.36$, $P = 0.0590$ for fall establishment and spring). The AGCO 20-in row spacing planted at 100,000 seeds acre^{-1} had the most surviving plants in the spring at 96,260 plants acre^{-1} (Table 2.5), however, it is important to note that fall density prior to winter was relatively high at 217,747 plants acre^{-1} (Table 2.4). Spring plant density for the AGCO

20-in row spacing at all seeding rates were significantly greater than the cooperator and AGCO 30-in treatments.

In contrast to Andale, spring densities at Kingman and Conway Springs increased with increasing seeding rates for both 20 and 30-in row spacing. Plant density for Stafford environment increased with increasing seeding rates only when row spacing was 20-in. Spring densities at the Kiowa environment did not differ due to seeding rate within the 20-in row spacing. However, in 30-in rows, spring plant density increased with increasing seeding rate. There was a positive correlation between fall establishment and spring stands at Kingman (r = 0.98, P = <0.0001) and Kiowa (r = 0.93, P = <0.0001). Overall, spring plant density increased with increasing seeding rates and fall stands in 2016, but stands decreased with increasing seeding rates in 2015 when seeding rates were substantially greater than desired. At three of the five environments, cooperator practices resulted in the greatest stands. The main effect of row spacing for AGCO treatments resulted in greatest spring stands in 20-in row spacing at every environment.

Winter survival

Treatment factors influenced winter survival at all environments (Table 2.6). Winter survival was minimal at Andale due to slightly above average temperatures in the fall followed by abrupt lows on November 11, 2014 (Figure 2.1), however seeding rates were greater than intended, resulting in spring densities great enough to produce suitable yields. Survival in Andale was greater in 20- compared to 30-in row spacing (Table 2.6). The cooperator 30-in rows had twice the rate of winter survival as the AGCO 30-in rows but had roughly half the number of plants in the fall. Winter survival increased with decreasing seeding rates in 20-in rows at four of the five environments. At Kiowa, winter survival also increased with decreasing seeding rates in 30-in row spacing treatments. Negative correlations between fall plant density and winter survival at

Andale (r = -0.36, P = 0.0590) and Stafford (r = -0.45, P = 0.0178) across all seeding rates and row spacings reinforce the concept that greater intra-plant competition within the row likely increases the probability of plant death over the winter. These results indicate that winter survival could be improved with narrower row spacing and reduced seeding rates.

Bloom progression

Bloom progression was not different across treatments at the Andale and Stafford environments (Table 2.6). However, at the Kingman environment, bloom progression was slower in the cooperator practice plots compared to the AGCO treatments. In Conway Springs, the cooperator treatment had the lowest percent of plants bloomed when compared to AGCO treatments, except for the 200,000 seeds acre^{-1} at 30-in row spacing. At Kiowa, seeding rate comparisons among AGCO treatments showed that percent of plants in bloom increased with increasing seeding rates as well as spring plant density. This could be due to increased branching in treatments with lower plant density and therefore less uniform blooming within plants. Row spacing did not influence percent bloom at any environment. In general, differences between treatments for bloom progression were not large even for environments were treatment factors significantly impacted blooming.

Yield

Yield differences between planting treatments within an environment were not large, however treatments did have a significant effect on yield at three of the five environments (Table 2.8). At Andale, the AGCO 20-in row spacing treatments ranked near the top at all seeding rates, and yields from 30-in rows tended to be less. Yields from the cooperator practice were intermediate and no different than any of the AGCO practices. The correlation analysis revealed a positive correlation between winter survival and yield (r = 0.32, P = 0.0958), where yield was greatest in plots that had the greatest winter survival. All AGCO treatments and the cooperator treatment used residue management practices at this environment. Yields at Stafford were less than achieved in other environments in 2016, likely due to poor pod set on the main raceme, reducing total pod number. In Stafford, row spacing and seeding rate had no effect on yield within the AGCO treatments, but several AGCO treatments yielded more than cooperator practice. Kingman yields increased as seeding rate decreased within the AGCO treatments regardless of row spacing, and all were superior to the cooperator treatment. At the Conway Springs and Kiowa environments, yields were not different regardless of equipment, row spacing or seeding rate. The relatively strong negative correlations between both fall establishment and spring stands versus yield at Kingman ($r = -0.84$, $P = <0.0001$ and $r = -0.85$, $P = <0.0001$, respectively) and at Conway Springs ($r = -0.49$, $P = 0.0125$ and $r = -0.46$, $P = 0.0188$, respectively) were likely related to plant stress resulting from periods of limited rainfall in fall and early spring at these environments (Figure 2.3 and 2.4). At Kiowa plants were under less drought stress (Figure 2.5), yields were greater, and there was a positive correlation between both fall establishment ($r = 0.36$, $P = 0.0706$) and spring stands ($r = 0.49$, $P = 0.0112$) versus yield. These contrasting correlations at different environments likely explain the lack of correlation observed when data from all environments were subjected to correlation analysis. In general, all AGCO treatments, including those with seeding rates substantially less than most cooperators' practice, produced yields that were either similar or greater than those achieved using cooperator practices across a wide range of yield levels.

Oil Concentration

Differences in oil concentration between treatment factors were not large, and treatments had a significant effect on oil concentration in only one environments (Table 2.9). At the Andale environment in 2014-15, oil concentration was greatest in the AGCO 20-in row treatment with the lowest seeding rate. In contrast, the cooperator practice treatment resulted in the lowest oil concentration. Within the AGCO treatments at Andale the 100,000 seeds acre^{-1} seeding rate was greater than the 150,000 seeds acre^{-1} seeding rate, but the 200,000 seeds acre^{-1} did not differ from either of the other two. In 2015-16 there were no differences between any AGCO treatments when compared to cooperator practice.

Discussion

In the 2014-15 growing season, temperatures were slightly above average in the fall, followed by an extreme temperature low that occurred throughout Kansas on November 11 (Figure 2.1). This resulted in five of the six environments being abandoned because average winter survival was less than 5%, however Andale averaged 30% winter survival and was harvested for yield. Holman et al. (2011) stated that final plant density is more critical for determining yield than fall density, but fall density and winter survival need to be sufficient for an adequate final plant density. In 2014-15, Andale fall establishment was significantly greater than targeted seeding rates, perhaps due to issues with planter calibration. Thus, establishment was as much as twice the targeted seeding rate (Table 2.4). Starting with that many plants resulted in adequate spring stands to achieve an acceptable yield even after a large percentage of plants were lost. With spring stands at Andale averaging 52,000 plants acre^{-1}, combined with canola's capacity to compensate for reduced stands, this environment was harvested for yield and averaged 31 bu acre^{-1} across treatments.

Rain was limited at all four environments after planting during the 2015-16 growing season with no substantial moisture events until December. Plants in two of the four environments, Stafford, and Kingman, exhibited substantial drought stress symptoms in late fall and again in early spring, likely related to soil texture (Table 2.1). Stafford had a loamy fine sand type and

Kingman a sandy loam type soil, which likely contributed too poor retention of soil moisture compared to the silt loam soils at the other environments.

It is important to consider the impact of residue management or the lack of, and the impact it could have on obtaining a successful crop. At Kingman and Kiowa both producers vertical tilled prior to planting for two reasons: weed control and winter survival. Therefore, when plots were planted at those environments residue was not heavy. At Stafford, the cooperator had concerns with moving adequate residue from the seed row, for that reason cooperator plots at that environment were strip tilled prior to planting. The cooperator practice at Conway Springs was to burn residue, and residue was considerably thick at this environment, however residue was left standing for both AGCO and cooperator plots. At Andale, the cooperator was concerned with getting good seed to soil contact while planting into residue, therefore cooperator plots at that environment were burned just prior to planting with residue being left for AGCO plots. Assefa et al. (2014) found that no-till plots had less yield than conventional tillage during one year of the study. Planting date is outside the scope of this study, however Assefa et al. (2014) found that the negative impact of no-till on yield was most pronounced in the last planting date compared with earlier planting dates, with a reduction of 96% versus 16 to 26% for earlier plantings. Canola producers must choose a form of residue management that works best for their production system, with that said it is important that residue is managed in some way.

Wider rows have the potential to allow for better fall establishment, but may also have an adverse effect on yield (Wysocki et al., 2009). The same authors looked at 24- and 30-in row spacing at 5 and 7-pound acre^{-1} seeding rates and found that winter canola fall establishment and yield did not significantly differ due to treatments. Wysocki et al. (2009) also looked 6 and 12-in row spacing with 5 and 7-pound acre^{-1} seeding rates and discovered that, in general establishment was greatest with the narrowest row spacing (6-in). In contrast, our study found that, regardless of row spacing, fall establishment number tended to follow seeding rates, increasing as seeding rates increased. However, the 20-in row spacing had greater establishment when compared to 30-in rows within the AGCO treatments at three of the five environments (Table 2.4). When compared to the AGCO treatments, cooperator practice produced the greatest fall establishment where row spacings were 10, 12, and 15-in (Table 2.4), in addition cooperator seeding rates were greater than for all AGCO treatments at these environments. This held true for spring stand values. However, in contrast to fall establishment, when considering the spring stand main effects of AGCO row spacing treatments, 20-in rows at all five environments had greater stands when compared to 30-in rows.

Few research experiments have examined the effects of management practices such as seeding rate and row spacing on winter survival of canola. Results from the current set of experiments showed that winter survival was greatest for AGCO treatments with 20-in rows at 100,000 seeds acre^{-1} rate at four of the five environments and was significantly better than all other treatments at two of the five environments when compared to cooperator practice. At three of the five environments, winter survival was better in 20- versus 30-in rows. These results could possibly indicate that 20-in rows resulted in less plant-to-plant competition, improving winter survival. In 2014-15 at the Andale environment, winter survival averaged 26% across treatments. Although winter survival can provide a useful comparison of fall and spring plant density numbers; it may not be as important as considering spring plant density. This is especially true in a scenario where the number of plants started out very high in the fall and dropped severely over the winter, but spring density is still high enough to produce acceptable yields. Alternatively, winter survival calculations could produce numbers that appear respectable, but if fall density is low, spring plant density could limit yield.

Canola will continue to flower on the main stem for approximately 2 to 4 weeks under normal growing conditions (Stamm et al., 2012). During blooming at Kingman, plants bloomed in approximately 3 flushes where plants continued to bloom while pods were maturing, which could have been attributed to rainfall events received during that time (Figure 2.3). This occurred throughout the field and could not be visually attributed to treatments. The progression of blooming is important to note due its impact on uniformity of seed maturity at the time of harvest, which can also can affect seed quality and oil content. However, our treatments had no impact on oil content at four of the five environments, and it was inconsistent at the remaining environment.

Environmental factors such as weather can have a large impact on yield. Wysocki et al. (2009) found that in the first year of their study 6- and 12-in row spacing had greatest yields, while 24- and 30-in rows had the poorest yields. As in our study, row spacing had little effect on yield in the second year of the Wysocki et al. (2009) study. The same authors attributed this to cooler weather and more late-season rains during the second year of this study, allowing plants to better compensate than in the first year. In our study, rainfall was limited in both years from December through April. Yields in Stafford may reflect the lack of moisture during bloom and pod set. Moisture patterns were similar at Andale in 2014-15, however the soil texture was more favorable for retaining moisture at that environment. Cooler temperatures and consistent late season rains promoted favorable conditions for winter canola yield formation.

Treatment factors did not influence yield at every environment. There were significant differences in yield at three of the five environments, where AGCO treatments were as good as or better than the cooperator practices. In contrast to results presented by Wysocki et al. (2009), our study showed a seeding rate differential at two of the five environments where 100,000 seed acre^{-1} produced greater yields than 150,000 seeds acre^{-1} and they both produced greater yields than 200,000 seeds acre^{-1}. Morrison et al. (1990) reported higher yields obtained from narrower rows as a product of more uniform plant distribution in spring canola. A row spacing differential was observed at the Andale environment where AGCO 20-in row spacing out yielded 30-in AGCO row spacing. During late bloom and early pod set it was evident at the Stafford environment that there were very few pods on the main raceme, which resulted in decreased yields. Plots in Stafford were close to full bloom on April 7th, during that time some lower temperatures occurred along with very little rainfall, which could have attributed to reduced pod set. Although Stafford resulted in relatively low yields averaging 17 bu acre^{-1}, Kiowa averaged 63 bu acre^{-1}. Yields were as good or better than cooperator practices at the three environments were treatment factors influences yield.

Oil concentration is an indication of grain quality and was examined in this study to determine if there was any impact of the treatments on quality. It could be expected that plants in lower populations that have room to branch would have less uniform pod maturity at harvest, leading to variable seed maturity and causing a reduction in oil percent. Based on the results from this study, seeding rate and row spacing had a minimal impact on oil content. Assefa et al. (2014) found that environment was the greatest source of variation for oil content, when compared to other sources of variation such as genetics. The percent oil content values collected in this study were consistent with the mean of 39% reported by Assefa et al. (2014).

Conclusions

The objective for this study was to compare AGCO's innovative residue management system to canola producers existing no-till residue management system. Our hypothesis was that

AGCO's residue management systems could allow planting canola into heavy residue, resulting in improved winter survival. The AGCO planter did a suitable job of moving heavy residue out of the seed row and placing it between the rows anchored by a small amount of soil. Thus, this system performed as good as or better than cooperator residue management practices for winter survival. The second objective was to determine the effect of row spacing and seeding rate on stand establishment, winter survival, and yield. With this objective in mind our hypothesis was that, as row spacing increases, within-row plant spacing decreases, increasing plant-to-plant competition and potentially reducing winter survival and yield. Cooperator practice tended to produce the greatest fall and spring plant densities, unless the AGCO seeding rate was greater than targeted (Andale). It is important to note that in general cooperator practice was greater seeding rates when compared to AGCO treatments. With the AGCO system winter survival tended to increase as seeding rate decreased in 20-in rows at four of the five environments. This could have been a result of wider intra-row plant spacing achieved with narrower rows. Yields results from the AGCO system treatments were as good as or better than yields produced by cooperator treatments. The lack of consistency for correlations between fall establishment, spring stand, and yield across environments indicates the important role that precipitation patterns and soil moisture can play in crop response. Even so, these results indicate that seeding rates can be reduced from those typically used by canola cooperators in high residue, no-till systems if residue can be adequately removed from the seed row.

References

Assefa, Y., Roozeboom K., Stamm, M. 2014. Winter canola yield and survival as a function of environment, genetics, and management. Crop Sci. 54:2303-2313.

Bradley, K.W. 2006. A review of the effects of row spacing on weed management in corn and soybean. [Online] Crop Manage. Doi:10.1094/CM-2006-0227-02-RV.

Christensen, J.V., J.C. Drable. 1984. Effect of row spacing and seeding rate on rapeseed yield in northwest Alberta. Can. J. Sci. 64: 1011-1013.

Epler, M., S. Staggenborg. 2008. Soybean yield and yield component response to plant density in narrow row systems. Crop Manage. Doi: 10.1094/CM-2008-0925-01-RS.

Hansen N. C., B. L. Allen, R. L. Baumhardt, D. J. Lyon. 2012. Research achievements and adoption of no-till, dryland cropping in the semi-arid U.S. Great Plains. Field Crop Res. 132, 196–203.

Holman, J., S. Maxwell, M. Stamm, K. Martin. 2011. Effects of planting date and tillage on winter canola. Online. Crop Manage. doi:10.1094/CM-2011-0324-01-RS.

Jiang, H., L. Zhu, J. Dai, T. Song, Y. Yan, S. Chen. 2005. Analysis of protein, starch, and oil content of single intact kernels by near infrared reflectance spectroscopy (NIRS) in maize (*Zea mays* L.). J. Plant Breeding, Blackwell Verlag, Berlin. Doi: 10.111/j.1439-0523.2007.01338.

Johnson, B.L., and B.K. Hanson. 2003. Row-spacing interactions on spring canola performance in the northern Great Plains. Agron. J. 95:703-708.

Kutcher, H.R., T.K. Turkington, G.W. Clayton, and K.N. Harker. 2013. Response of herbicide-tolerant canola (*Brassica napus* L.) cultivars to four row spacings and three seeding rates in a no-till production system. Can. J. Plant Sci. 93:1229-1236.

Morrison, M.J., P.B.E. McVetty, and R. Scarth. 1990. Effect of row spacing and seeding rates on summer rape in southern Manitoba. Can. J. Plant Sci. 70:127-137.

Stamm, M., J. Bushong., H. Sanders., M. Boyles. 2012. Great Plains canola production handbook. Kansas State University [Online]. http://www.bookstore.ksre.ksu.edu/pubs/mf2734.pdf.

Wysocki, D., N. Sirovatka. 2009. Growing Canola on Wide Row Spacing. Oregon Agric. Exp. Station Spec Rep 879:50-55.

Yang, R.-C., and P. Juskiw. 2011. Analysis of covariance in agronomy and crop research. Can. J. Plant Sci. 91: 621-641.

Young, F.L., W.L. Whaley, R. Pan, D. Roe, J.R. Alldredge. 2014. Introducing Winter Canola to the Winter Wheat-Fallow Region of the Pacific Northwest. Crop Mange. Dio:10.2134/CM-2013-0023-RS.

Figures

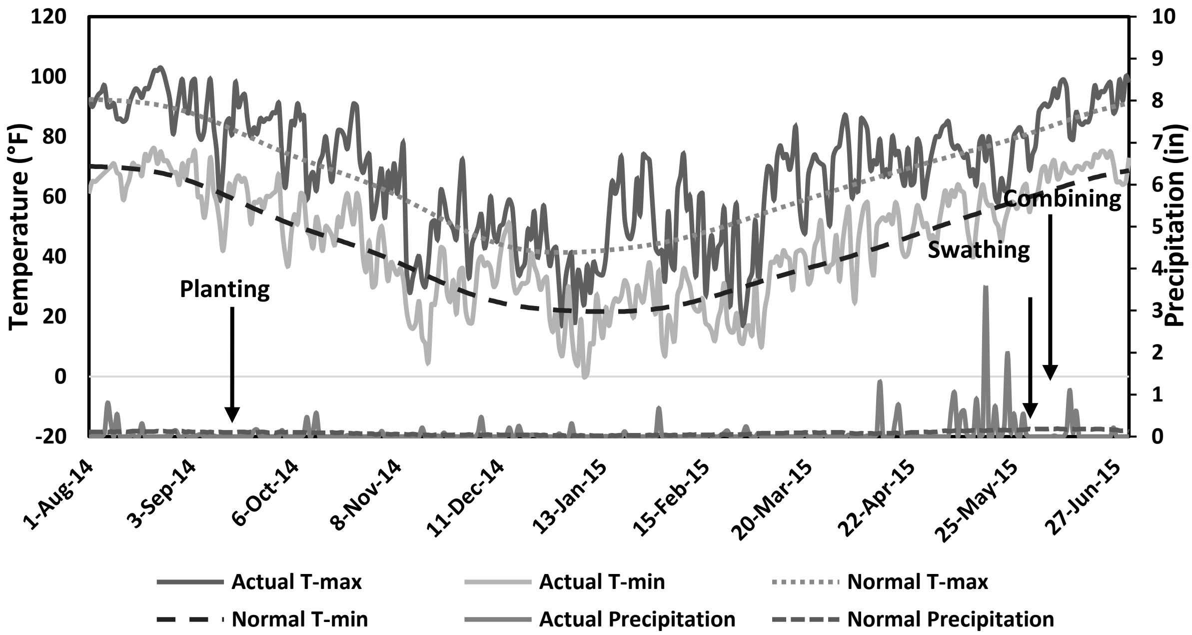


Figure 2.1. Temperatures and precipitation for Andale, KS, 2014-15 growing season.

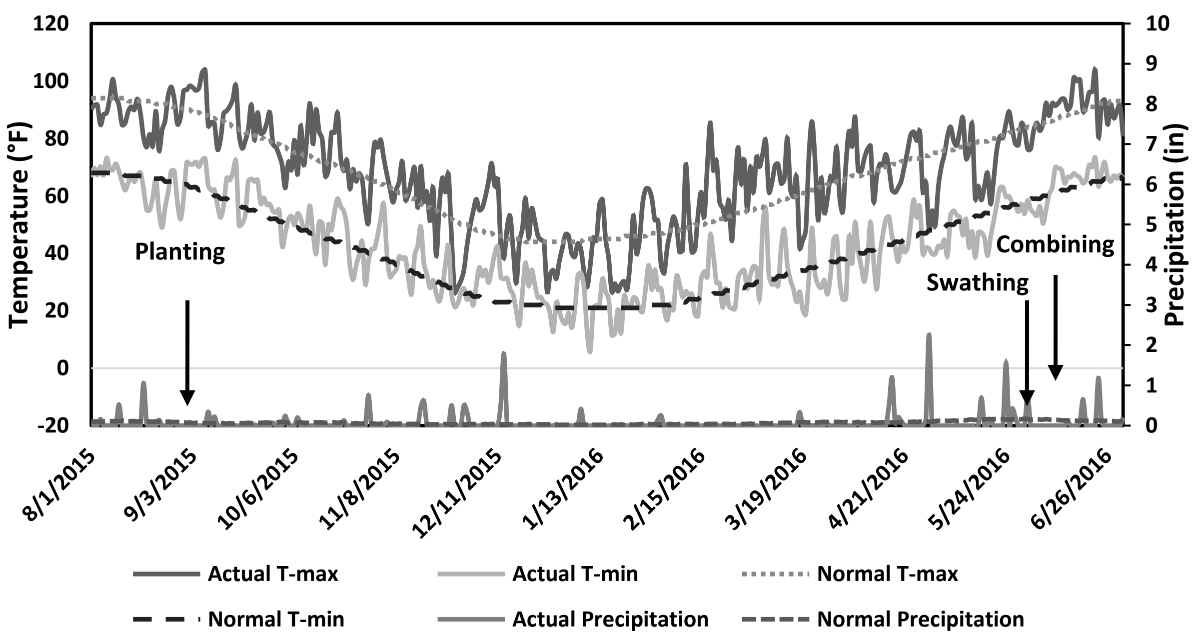


Figure 2.2. Temperatures and precipitation for Stafford, KS, 2015-16 growing season.

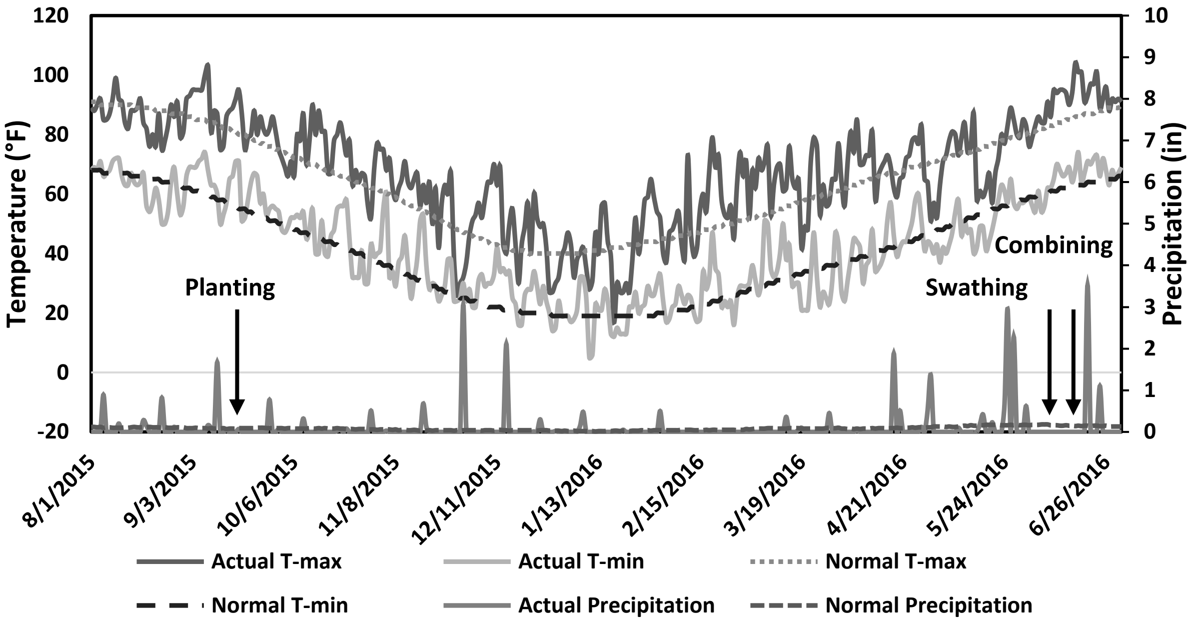


Figure 2.3. Temperatures and precipitation for Kingman, KS, 2015-16 growing season.

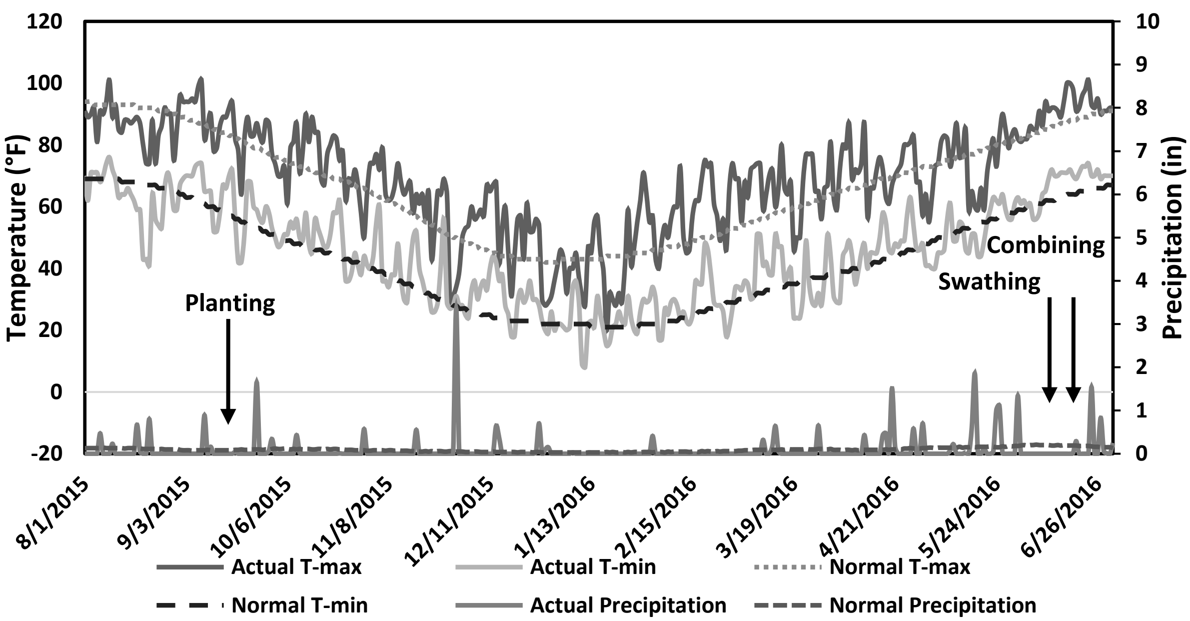


Figure 2.4. Temperatures and precipitation for Conway Springs, KS, 2015-16 growing season.

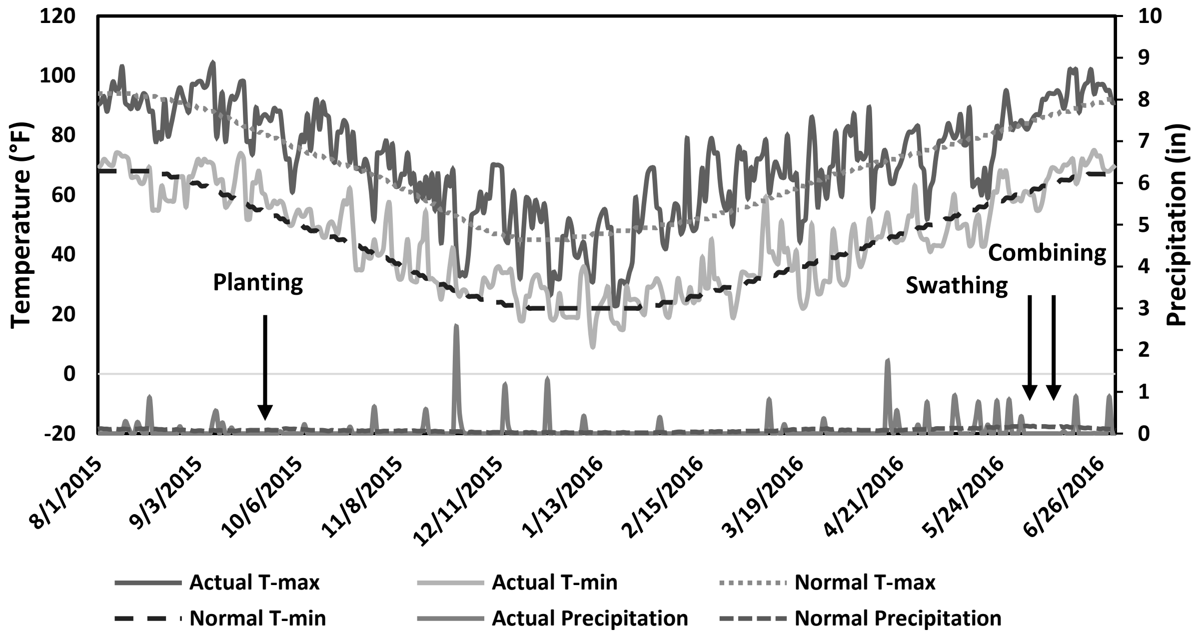


Figure 2.5. Temperatures and precipitation for Kiowa, KS, 2015-16 growing season.

Tables

Table 2.1. Field operations for five Kansas 2014-2016 environments, comparing AGCO Corp's residue management system with row spacing and seeding rate comparisons to existing no-till residue management system.

Management factor	Andale 2014-15	Stafford 2015-16	Kingman 2015-16	Conway Springs 2015-16	Kiowa 2015-16
Residue management	Burned	Strip tillage	Vertical tillage	No-till	Vertical tillage
Planting equipment	John Deere 1750 row crop planter	John Deere 1790 row crop planter	John Deere 1890 air drill, /disk openers	John Deere 1790 row crop planter	John Deere 1870 air hoe drill, Conservapak hoe openers
Row spacing (inches)	30	30	10	15	12
Cultivar	Mercedes	HyClass 115 W	DKW 44-10	HyClass 125 W	DKW 45-25
Seeds acre^{-1}	191 600	312 500	684 000	562 500	380 000
Planting	September 19	September 11	September 14	September 17	September 25
Fertilizer, -Fall lb a^{-1} N-P_2O_5-K_2O-S	25-15-0-5	30-30-30-32		None	30-40-0-10
Fertilizer, -Spring lb a^{-1} N-S	47-9	11-0-0-22		73-8	30-8.5
Swathing	June 21	June 1	June 4	May 29	June 4
Harvest	June 25	June 6	June 9	May 30	May 7
Grain weight	Weigh wagon	Green Star™ Harvest Monitor™	Weigh wagon	Ag Leader Yield Monitoring	Grain cart with scales

Table 2.2. Environment soil descriptions for ten Kansas 2014-2016 environments, comparing AGCO Corp's residue AGCO Corp's residue management system with row spacing and seeding rate comparisons to existing no-till residue management system.

Year	Environment	Coordinates	Previous residue	†Soil Series	†Soil Classification
2014-15	Concordia	39.51682, -97.62438	Corn	Muir silt loam	Fine-silty, mixed, superactive, mesic Cumulic Haplustolls
2014-15	Andale	37.74832, -97.67961	Wheat	Blanket silt loam	Fine, mixed, thermic Pachic Argiustolls
2014-15	Yoder	38.01323, -97.82936	Wheat	Darlow-Elmer complex	Fine-loamy, mixed, superactive, mesic Vertic Natrustalfs
2014-15	Hesston	38.13074, -97.44215	Corn	Ladysmith silty clay loam	Fine, smectitic, mesic Pachic Udertic Argiustolls
2014-15	Montezuma	37.68341, -100.43752	Corn	Manter fine sandy loam	Coarse-loamy, mixed, mesic Aridic Argiustolls
2014-15	Kiowa	36.96738, -98.49191	Wheat	Pond Creek silt loam	Fine-silty, mixed, superactive, thermic Pachic Argiustolls
2015-16	Stafford	37.8883, -98.82021	Wheat	Hayes-Turon; Pratt-Carwile complex	Course-loamy, mixed, superactive, mesic Udic Haplustalfs; Sandy, mixed, mesic Lamellic Haplustalfs
2015-16	Kingman	37.68434, -98.17162	Wheat	Shellabarger sandy loam	Fine-loamy, mixed, superactive, mesic Udic Argiustolls
2015-16	Conway Springs	37.3858, -97.60229	Wheat	Kirkland silt loam; Renfrow-Grainola complex	Fine, mixed, superactive, thermic Udertic Paleustolls; Fine mixed, thermic Udertic Paleustolls
2015-16	Kiowa	36.95688, -98.49779	Wheat	Pond Creek silt loam	Fin-silty, mixed, superactive, thermic Pachic Argiustolls

†United States Department of Agriculture; Natural Resources Conservation Service.

Table 2.3. Pre-dormancy leaf number comparing AGCO Corp's residue management at two row spacings and three seeding rates to existing no-till residue management systems at five Kansas environments 2014 and 2015.

Environment	AGCO planter						Cooperator practice
	20-in row spacing			30-in row spacing			
	Seeding rate (seeds acre^{-1})			Seeding rate (seeds acre^{-1})			
	100,000	150,000	200,000	100,000	150,000	200,000	
	leaves						
Andale 2014	4.7 b†	5.0 a	5.0 a	4.9 a	4.3 c	4.9 a	4.0 d
Stafford 2015	3.5 c	4.5 a	4.7 a	3.5 c	3.7 bc	3.7 bc	3.9 b
Kingman 2015	4.7 a	3.7 d	4.0 c	4.0 c	4.3 b	4.3 b	4.0 c
Conway Springs 2015	3.0 b	3.3 a	3.3 a	3.0 b	3.3 a	3.3 a	3.4 a
Kiowa 2015	2.7 b	2.7 b	2.3 c	3.0 a	3.0 a	2.3 c	2.9 a

	Seeding rate (seeds acre^{-1})			Row spacing	
	100,000	150,000	200,000	20-in	30-in
Andale 2014	4.8 ab†	4.6 b	5.0 a	4.9 a†	4.7 b
Stafford 2015	3.5 b	4.2 a	4.1 a	4.2 a	3.6 b
Kingman 2015	4.3 a	4.0 b	4.2 ab	4.1	4.2
Conway Springs 2015	3.0 b	3.3 a	3.3 a	3.2	3.2
Kiowa 2015	2.8 a	2.8 a	2.3 b	2.6 b	2.8 a

†Values within a row followed by the same letter are not different at $\alpha = 0.10$.

Table 2.4. Fall plant establishment comparing AGCO Corp's residue management with two row spacings and three seeding rates to existing no-till residue management systems at five Kansas environments 2014 and 2015.

	AGCO planter						
	20-in row spacing			30-in row spacing			
Environment	Seeding rate (seeds acre^{-1})			Seeding rate (seeds acre^{-1})			Cooperator
	100,000	150,000	200,000	100,000	150,000	200,000	Practice
	plants acre^{-1}						
Andale 2014	217,747 bc†	244,965 b	310,024 a	154,495 d	201,814 c	236,335 b	115,365 e
Stafford 2015	111,895 c	139,501 b	169,013 a	107,593 cd	81,748 d	93,654 cd	135,375 b
Kingman 2015	122,186 bc	122,839 bc	133,294 b	70,567 e	86,684 ed	105,125 cd	236,240 a
Conway Springs 2015	52,272 d	71,003 c	90,823 b	51,256 d	60,548 cd	90,460 b	200,046 a
Kiowa 2015	72,527 de	91,040 cd	93,872 c	67,808 e	95,542 c	114,853 b	190,108 a

	Seeding rate (seeds acre^{-1})			Row spacing	
	100,000	150,000	200,000	20-in	30-in
Andale 2014	186,103 c†	223,390 b	273,179 a	257,579 a†	197,536 b
Stafford 2015	109,982	123,856	119,205	140,803 a	94,559 b
Kingman 2015	96,377 b	104,762 b	119,209 a	126,106 a	87,459 b
Conway Springs 2015	51,746 c	65,776 b	90,641 a	71,366	67,421
Kiowa 2015	70,168 b	93,291 a	104,363 a	85,813	92,734

†Values within a row followed by the same letter are not different at α = 0.10.

Table 2.5. Spring plant density comparing AGCO Corp's residue management with two row spacings and three seeding rates to existing no-till residue management systems at five Kansas environments 2014 and 2015.

Environment	AGCO planter 20-in row spacing Seeding rate (seeds acre^{-1}) 100,000	150,000	200,000	AGCO planter 30-in row spacing Seeding rate (seeds acre^{-1}) 100,000	150,000	200,000	Cooperator Practice
	plants acre^{-1}						
Andale 2015	96,260 a†	79,000 b	59,084 c	29,210 d	29,653 d	34,078 d	37,914 d
Stafford 2016	79,465 bc	87,035 ab	95,205 a	59,197 de	48,497 e	56,892 e	70,277 cd
Kingman 2016	80,368 de	107,375 bc	116,523 b	59,096 f	68,825 ef	91,766 cd	206,910 a
Conway Springs 2016	44,649 d	57,717 cd	68,825 b	39,494 d	47,771 cd	58,806 bc	150,830 a
Kiowa 2016	66,429 b	71,656 b	64,033 bc	47,045 d	53,288 cd	64,324 bc	140,235 a

Environment	Seeding rate (seeds acre^{-1}) 100,000	150,000	200,000	Row spacing 20-in	30-in
Andale 2015	62,735	54,326	46,581	78,114 a†	30,980 b
Stafford 2016	69,288	66,937	79,479	88,844 a	54,958 b
Kingman 2016	69,732 c†	88,100 b	104,145 a	101,422 a	73,229 b
Conway Springs 2016	40,072 c	52,744 b	63,815 a	57,064 a	48,690 b
Kiowa 2016	56,737	62,472	64,178	67,373 a	54,886 b

†Values within a row followed by the same letter are not different at $\alpha = 0.10$.

Table 2.6. Winter survival comparing AGCO Corp's residue management with two row spacings and three seeding rates to existing no-till residue management systems at five Kansas environments 2014 and 2015.

	AGCO planter						
	20-in row spacing			30-in row spacing			
Environment	Seeding rate (seeds acre^{-1})			Seeding rate (seeds acre^{-1})			Cooperator
	100,000	150,000	200,000	100,000	150,000	200,000	Practice‡
	percent						
Andale 2015	47.9 a†	34.7 b	18.9 c	21.1 c	15.2 c	15.5 c	34.1 b
Stafford 2016	74.7 a	66.6 ab	60.6 bc	55.1 bc	66.8 ab	61.2 bc	53.9 c
Kingman 2016	69.4 c	86.8 ab	88.2 ab	84.9 ab	81.2 b	89.2 a	87.6 ab
Conway Springs 2016	86.4 a	81.4 ab	75.5 b	77.5 b	80.4 ab	66.0 c	76.5 b
Kiowa 2016	92.2 a	80.3 b	69.5 c	72.9 bc	57.4 d	56.9 d	75.9 bc

	Seeding rate (seeds acre^{-1})			Row spacing	
	100,000	150,000	200,000	20-in	30-in
Andale 2015	34.5 a†	24.9 b	17.2 b	33.8 a†	17.3 b
Stafford 2016	64.9	62.2	66.3	67.9	61.0
Kingman 2016	77.2 b	84.0 a	88.7 a	81.4	85.1
Conway Springs 2016	82.0 a	80.9 a	70.8 b	81.1 a	74.7 b
Kiowa 2016	82.5 a	68.9 b	63.2 b	80.6 a	62.4 b

†Values within a row followed by the same letter are not different at α = 0.10.

Table 2.7. Bloom progression comparing AGCO Corp's residue management with two row spacing and three seeding rates to existing no-till residue management systems at five Kansas environments 2014 and 2015.

Environment	AGCO planter						Cooperator Practice
	20-in row spacing			30-in row spacing			
	Seeding rate (seeds acre^{-1})			Seeding rate (seeds acre^{-1})			
	100,000	150,000	200,000	100,000	150,000	200,000	
	percent						
Andale 2015	35.0	35.0	43.3	51.6	43.3	33.3	50.5
Stafford 2016	74.4	70.1	66.9	70.4	71.7	68.1	65.0
Kingman 2016	53.3 a†	55.0 a	50.0 a	53.3 a	48.3 a	53.3 a	40.5 b
Conway Springs 2016	41.7 a	36.7 ab	33.3 ab	38.3 ab	38.3 ab	28.3 bc	22.1 c
Kiowa 2016	90.0 bc	95.0 ab	95.0 ab	85.0 c	91.7 abc	98.3 a	90.6 bc

	Seeding rate (seeds acre^{-1})			Row spacing	
	100,000	150,000	200,000	20-in	30-in
Andale 2015	43.3	39.2	38.3	37.7	42.7
Stafford 2016	72.5	71.7	65.4	69.7	70.0
Kingman 2016	53.3	51.7	51.7	52.8	51.7
Conway Springs 2016	40.0	37.5	30.8	37.2	35.0
Kiowa 2016	87.5 b†	93.3 ab	96.7 a	93.3	91.7

†Bloom progression was measured as a visual observation of how many plants were in bloom approximately two months prior to harvest.

Table 2.8. Yield comparing AGCO Corp's residue management with two row spacings and three seeding rates to existing no-till residue management systems at five Kansas environments 2014 and 2015.

Environment	AGCO planter						Cooperator Practice
	20-in row spacing			30-in row spacing			
	Seeding rate (seeds acre^{-1})			Seeding rate (seeds acre^{-1})			
	100,000	150,000	200,000	100,000	150,000	200,000	
	bu acre^{-1}						
Andale 2015	34.5 a†	33.4 ab	31.9 abc	29.9 bc	27.7 c	30.3 abc	32.2 abc
Stafford 2016	17.4 a	16.2 ab	16.8 ab	18.3 a	16.3 ab	22.3 a	12.5 b
Kingman 2016	24.2 a	21.9 ab	20.2 b	23.1 a	22.1 ab	19.9 b	15.7 c
Conway Springs 2016	23.5	23.6	23.1	23.2	23.7	23.3	21.9
Kiowa 2016	63.5	62.6	61.7	63.5	62.6	61.7	65.6

	Seeding rate (seeds acre^{-1})			Row spacing	
	100,000	150,000	200,000	20-in	30-in
Andale 2015	32.2 a†	30.5 b	31.2 c	33.3 a†	29.3 b
Stafford 2016	17.7	16.3	19.8	19.0	16.8
Kingman 2016	23.6 a	22.0 b	20.1 c	22.1	21.7
Conway Springs 2016	23.4	23.7	23.2	23.4	23.4
Kiowa 2016	63.5	62.6	61.7	62.6	62.6

†Values within a row followed by the same letter are not different at $\alpha = 0.10$.

Table 2.9. Oil concentration comparing AGCO Corp's residue management with two row spacings and three seeding rates to existing no-till residue management systems at five Kansas environments 2014 and 2015.

Environment	AGCO planter						Cooperator Practice
	20-in row spacing			30-in row spacing			
	Seeding rate (seeds acre^{-1})			Seeding rate (seeds acre^{-1})			
	100,000	150,000	200,000	100,000	150,000	200,000	
	percent						
Andale 2015	41.1 a†	39.9 bc	40.5 ab	40.5 ab	39.8 bc	40.5 ab	39.5 c
Stafford 2016	41.4	40.4	43.1	41.5	40.7	40.4	40.1
Kingman 2016	42.7	42.1	43.2	43.2	43.1	42.4	42.8
Conway Springs 2016	41.2	40.0	40.5	42.1	42.2	41.5	42.2
Kiowa 2016	41.6	40.0	41.0	40.8	42.1	41.5	42.1

	Seeding rate (seeds acre^{-1})			Row spacing	
	100,000	150,000	200,000	20-in	30-in
Andale 2015	40.8 a	39.8 b	40.5 ab	40.5	40.3
Stafford 2016	41.4	40.8	42.1	42.0	40.9
Kingman 2016	43.0	42.6	42.8	42.7	42.9
Conway Springs 2016	41.6	41.0	41.0	40.5	41.8
Kiowa 2016	41.2	41.1	41.2	40.1	41.4

†Values within a row followed by the same letter are not different at $\alpha = 0.10$.

Chapter 3 - Genotype and Seeding Rate Interactions for Winter Canola in 30-inch Row Spacing

Abstract

The improvement of winter canola genetics (*Brassica napus* L.) in recent years has brought about questions regarding best management practices such as optimal seeding rates and row spacing as a practice to manage residue. The objective of this study was to determine the effect of seeding density on winter survival and yield of hybrid and open-pollinated winter canola cultivars in 30-in rows. This experiment was conducted in 2014-15 and 2015-16 at two Kansas State University Research and Extension facilities. Treatments were four genotypes and five seeding rates for a total of twenty treatments. Due to winter stand loss, experiments were not harvested for yield in 2015. All three environments in the 2015-16 growing season were harvested for yield. In most cases, fall establishment and spring densities at each environment increased with increasing seeding rate. Winter survival increased as seeding rate decreased at the Manhattan environment. Seeding rates of 100,000 to 400,000 seeds acre^{-1} did not impact yield at any environment. Yield differences between genotypes were significant only in the Manhattan, KS environment. These results indicate that seeding rates can be reduced from those typically used by canola producers in high residue, no-till or reduced tillage systems if residue can be adequately removed from the seed row. Both hybrid and open-pollinated winter canola cultivars responded similarly to seeding rate in 30-in rows in these experiments, indicating that similar seeding rates could be used for each type of cultivar.

Introduction

Rapeseed was first grown extensively in Canada in the early 1940's for industrial purposes (Brandt et al., 2007). Early plant breeding efforts focused on improving the quality of the oil for human and livestock consumption. These genetic modifications to the quality of the rapeseed led to the development of what is known today as canola, which is simply a designation for rapeseed with low concentrations of uric acid (<2%) and glucosinolates (<30 μmol g^{-1}) (Brandt et al., 2007). In the 1970's, yield improvements to canola were modest, in addition many of the current production and management practices that producers use today were developed at that time. More recently, breeders have focused on improving agronomic traits in new cultivars, and with that there has been a substantial yield improvement. Brandt et al. (2007) suggests that revisions to management practices may be needed to realize the true value of the improved genetics.

A successful winter canola crop is achieved through the multifaceted interaction of genetics, management, and environment. One of the major differences between many cultivars on the market today is open-pollinated versus hybrid genotypes. One characteristic that separates the two cultivar types is seed size with hybrid seed tending to be larger (60,000 to 90,000 seeds/lb) than open pollinated seed (100,000 to 125,000 seeds/lb) (Stamm et al. 2012). Brandt et al. (2007) suggests that yield advantages of 40 to 72% have been achieved with hybrid versus open pollinated cultivars. Assefa at al. (2014) looked at varieties based on differences in agronomic factors such as yield potential, winter survival, , and crown height, among other characteristics and found that cultivar influenced yield, crown height, and winter survival. Crown height can be important when considering plant characteristics that contribute to increased winter survival because elevated crown heights can be associated with greater winter stand loss (Holman et al., 2011). Although Assefa et al. (2014) observed that cultivars differed in crown height, it did not appear to be correlated with hybrid verses open-pollinated cultivars. On the other hand, winter survival was 7% less for the hybrid variety than for the lowest ranking open pollinated variety in their data set. Hybrid cultivars had the yield advantage for the earliest planting dates in nearly all years of the study. This could be attributed to hybrid vigor, which can lead to more aggressive vegetative growth.

Although much research has been done on the effects of optimal seeding rates with spring canola, little research has been conducted for winter canola on stand establishment and winter survival (Young et al., 2013). Plant density response to seeding rate is one important factor. Christensen et al. (1984) proposed that the reason such high seeding rates historically have been proposed for summer rapeseed is too ensure a large enough plant density at early growth stages to be competitive with weeds. The advantage of high inter-species competition may be offset, by a higher intra-species competition, potentially resulting in similar yield loss (Christensen et al., 1984). Young et al. (2013) found that yield was almost 20% greater at the 4-lb acre^{-1} compared with the 8-lb acre^{-1} rate, even though greatest fall and spring densities were achieved at the 8-lb acre^{-1} rate, indicating that intraspecific competition reduced winter canola yield.

Many researchers and producers are interested to know if genetics can boost productivity with best management practices and if best management practices change depending on genetics. In recent years breeding, has focused on improving agronomic traits, because of this Brandt et al. (2007) suggests that revisions may need to be made to management practices to realize the true value of the improved genetics. The same authors also suggested that there might be a possible need for separate sets of management practices for hybrid and open pollinated cultivars. Early researchers of hybrid canola believed that the observed yield increase from high parent heterosis would be sufficient to ensure that a large-scale switch to hybrids would occur at some point (McVetty, 1995).

Canola can be a particularly challenging crop when it comes to winter survival in no-till cropping systems (Young et al., 2013). An important decision in terms of agronomic practices for canola in no-till production includes the management of residue left from the previous year's crop. The success of direct seeding winter canola into wheat residue has received criticism in recent years due to extreme winter stand loss (Holman et al., 2011). If seed to soil contact is poor, the roots may not penetrate the soil surface and simply develop underneath the residue. Placing the seed too shallow and not penetrating the soil surface will result in a shallow rooted canola plant, and lengthening of the crown above the soil surface, making the plant susceptible to winter kill (Holman et al., 2011). Crown height is an important factor for winter survival, the closer the crown is to the soil surface, the chances for adequate winter survival increase greatly (Holman et al., 2011). To mitigate these effects, adequate seed to soil contact is important, when directly seeding into undisturbed heavy residue (Holman et al., 2011). This is largely an issue that must be resolved at planting. Moving residue and surface soil away from the row can mitigate the negative effects of residue coverage (Wysocki et al., 2009). There are various ways to mitigate the effect of residue through either removal by burning or tillage, or by managing it with planting equipment.

The use of planting equipment to manage residue can more beneficial when compared to other methods due to maintaining residue between rows and reduced passes across the field. When comparing, and contrasting wide versus narrow row spacing, there are benefits and risks associated with both. Wider rows have the potential to better prepare the seed row, allowing for increased stand establishment (Wysocki et al., 2009), but wider row spacing may have an adverse effect on yield. Narrower row width can provide quicker canopy closure, reducing weed competition, and lessening wind shattering before harvest (Wysocki et al., 2009). However, increasing light interception associated with narrow row spacing may also result in cooler soil temperatures. Potential benefits to using row crop planting equipment with wider row width for no-till canola production includes: better residue management over the row, less soil disturbance, and more precise seed placement (Kutcher et al., 2013).

The objective of this study was to determine optimum seeding rates for open pollinated and hybrid genotypes in 30-in row spacing. We hypothesized that hybrids should emerge more quickly, resulting in increased fall growth at lower seeding rates. Therefore, optimum seeding rates for open pollinated and hybrid cultivars in 30-in rows will be different.

Materials and Methods

This study was conducted in 2014-15 and 2015-16 at three environments located at two Kansas State University Research and Extension facilities: The North Agronomy Farm, Manhattan, KS and the South-Central Experiment Field near Hutchinson, KS in both 2014 and 2015 (Table 3.1). The annual high temperature for the Manhattan environment is 67.2 °F and annual low is 42.6 °F, with an average annual rainfall of 35.5-in (U.S Climate Data, 2016) (Figure 3.1). At the Hutchinson environment, the annual high temperature is 67.2 °F and the annual low is 42.8 °F with an average annual rainfall of 30.65-in (U.S Climate Data, 2016) (Figure 3.2).

Fertilizer rates were based on university Extension recommendations for winter canola (Stamm et al., 2012). In 2015-16 no fall applied nitrogen was needed at the Hutchinson environment as soil tests indicated that the residual level was 92 lb acre^{-1} in the 0 to 24-in profile. Plots were scouted for weeds and insects on a weekly to biweekly basis. Plots in Hutchinson were sprayed with Select Max (Valent Corp. Walnut Creek, CA) at a 12 oz acre^{-1} rate on March 11th and Manhattan plots were sprayed with Assure II (DuPont Pioneer Johnston, IA) at a 9 oz acre^{-1} rate on March 9th.

All plots were planted into 30-in rows, four rows per plot, at a length of 30 feet. The experimental design was a randomized complete block with two factors: four genotypes and five seeding rates. To accommodate differences in capabilities of planting equipment at the two environments, treatment structures differed between environments in 2015-16. Treatments were arranged in a split plot treatment structure in 2014-15 at both Manhattan and Hutchinson, and 2015-16 at the Manhattan environment, with seeding rate as the whole plot and genotype as the subplot. In both Hutchinson environments (no-tilled and tilled) in 2015-16, treatments were arranged in a factorial treatment structure with all combinations of genotype and seeding rate randomly assigned to experimental units within each replication. The combination of four genotypes and five seeding rates resulted in 20 treatments that were replicated four times. The four representative winter canola genotypes adapted to our environments were chosen to evaluate seeding rate responses consisted of cultivars suitable for Kansas growing conditions (Kansas State University, 2014). Two were open pollinated varieties: Riley (Kansas State University, Manhattan, KS) and DKW 44-10 (Monsanto, St. Louis, MO), and two were hybrids, Safran and Mercedes (DL Seeds Inc., Morden, MB, Canada). The hybrids will be abbreviated as (HYB) and open-pollinated as (OP) throughout the document. The seeding rate treatments were: 100 000, 175 000, 250 000, 325 000, and 400 000 seeds acre^{-1}.

Both 2014-15 environments, Manhattan, and Hutchinson, were no-till planted into wheat residue (Table 3.1). In the 2015-16 growing season, Manhattan was no-till planted into wheat residue as was one of two Hutchinson environments. The additional Hutchinson environment in 2015-16 was vertical tilled before planting. All experiments were planted with a Seed Research Equipment Solutions planter (SRES, South Hutchinson, KS) fitted with Monosem (Monosem Inc., Largeasse, France) seed meters and John Deere (Moline, IL) row units.

Methods to measure response variables were the same at all environments. Fall canola establishment was determined at the 3 to 4 leaf stage prior to dormancy from two 1-m lengths of row in the center two rows of each plot. The same areas were used to determine spring stands at or just before bolting. Bloom progression was recorded as a percent of plants bloomed within a plot once all plots had begun to bloom. The center two rows of each plot were swathed and windrowed with a 5-foot-wide plot swather (Swift Machine & Welding Ltd. Swift Current, SK, Canada) and allowed to dry approximately seven days. Plots were harvested with a Massey Ferguson 8XP combine (Kincaid Manufacturing, Haven, KS). Plot seed yield, moisture, and test weight data were recorded with a Harvest Master Classic GrainGage (Juniper Systems Inc., Logan, UT) using Mirus 3.1 (Juniper Systems Inc., Logan, UT) harvest data collection software. Grain yields were standardized to a consistent moisture content of 8%. Grain samples were collected at harvest, and a subsample was sent to the Brassica Breeding and Research program at the University of Idaho for NIRS (near-infrared spectroscopy) oil content estimation analysis (Jiang et al., 2005).

Analysis of variance (ANOVA) was conducted separately for each environment given differences in experimental design, using the PROC GLIMMIX procedure, $\alpha = 0.1$ in SAS 9.4 (SAS Institute, 2014) to determine the significance of treatment factors and interactions. Genotype and seeding rate and their interaction were fixed effects; replication was a random effect. Due to the split-plot treatment structure at Manhattan 2015-16, the replication x seeding rate interaction was used as the error term (Error A) to test for seeding rate effects, and the residual error was used to test for genotype and interaction effects. Regression analysis was performed based on cultivar groupings derived from an iterative ANOVA process. In the case that the genotype by seeding rate interaction was significant ($\alpha = 0.1$), a subsequent ANOVA was conducted to test the type by seeding rate interaction to determine if differences in response to seeding rate could be captured, by cultivar type (hybrid or open pollinated). A third ANOVA was conducted to test the significance of genotype by seeding rate interaction within each type to determine if cultivars responded consistently within type. Regression analysis was performed on each cultivar, type, or some combination of the two, depending on ANOVA interaction results, to characterize their response(s) to seeding rate. A regression line was plotted when the model and coefficients were significant (Table 3.5, 3.6, and 3.7). Yields were plotted against fall establishment, spring stands, and winter survival to determine if relationships existed between measures of plant density or survival and yield. A Pearson correlation analysis was performed to determine the strength of correlations between variables, where yields were standardized at a percent of maximum at each environment. Correlation was performed within each environment separately and across the three environments. If the across environment analysis revealed results representative of the individual environments, results were presented across environments.

Results and Discussion

In the 2014-15 growing season, temperatures were slightly above average in the fall, followed by an extreme temperature low that occurred throughout Kansas on November 11 (Figure 3.1). With these conditions, plants did not have an adequate opportunity to gradually acclimate to low temperatures, reducing their freezing tolerance and ability to survive after a period of cold-temperature (Teutonico et al., 1993). Both the Manhattan and Hutchinson experiments were lost to winter kill in 2014-15.

In 2015-16 temperatures were mild through the growing season, not dipping into the single digits until January and allowing adequate time for acclimation to low temperatures (Figure 3.2). Rainfall was limited from late December through the middle of April at both environments. Late freeze events occurred in March and early April, terminating some early blooms. With the 30-in row spacing, weed management was a challenge in the no-till environments. At Hutchinson and Manhattan, the plant canopy developed noticeably slower than the Hutchinson environment that had been vertically tilled prior to planting, making weeds more difficult to manage throughout early vegetative stages in the spring. Herbicide treatments did not achieve adequate control; therefore, weeds were manually removed as needed until harvest. Volunteer wheat was an issue for no-till plots in both Manhattan and Hutchinson environments. Manually weeding plots by hand kept the weed competition at a level that did not influence plant development or yield. Plots were harvested for yield at all environments in 2015-16.

Fall establishment

Fall establishment is a measurement of the number of plants that resulted in response to a given treatment. At the Manhattan environment, there was an interaction between genotype and seeding rate for fall establishment, indicating a differential response to seeding rate (Table 3.2). The two open-pollinated cultivars did not differ from one another; however, the hybrids did, with Mercedes (HYB) being no different than the open-pollinated cultivars (Figure 3.3, Table 3.5). Safran (HYB) was different than all other genotypes in the experiment. The regression indicated that Safran establishment was slightly less responsive to seeding rate than for the other genotypes, but this was likely a result of poor establishment for this cultivar at the 325 000 seeds acre^{-1} (Figure 3.3). At the Hutchinson environment where residue was not tilled, the interaction between genotype x seeding rate was not significant (Table 3.3). However, genotype and seeding rate were significant for fall establishment. Hybrids had similar establishment, Safran (HYB) and Riley (OP) were no different, and both open-pollinated cultivars resulted in similar establishment (Figure 3.4a). Fall establishment increased as seeding rate increased, at least until the 325 000 seeds acre^{-1} seeding rate (Figure 3.4b). At the Hutchinson environment where residue was tilled, there was a genotype x seeding rate interaction (Table 3.4). Fall establishment was greatest for Mercedes (HYB) and Safran (HYB) at intermediate seeding rates, however Riley (OP) and DKW44-10 (OP) were no different at low to intermediate seeding rates (Figure 3.5). The regression indicates that the open-pollinated varieties established fewer plants than hybrids at greater seeding rates, while the hybrids showed little response to seeding rate.

Researchers have looked at row spacing and seeding rates comparable to our research and observed similar observations. In 2015-16 across environments fall establishment ranged from 36,000 to 144,000 plants acre^{-1}. Young et al. (2014) planted a hybrid cultivar and reported fall establishment values of 31,880-315,780 plants acre^{-1} in 28-in row spacing across 200,000 to 800,000 seeds acre^{-1}. In addition, Wysocki et al. (2009) observed fall establishment values of 192,000 to 579,000 seed acre^{-1} in response to seeding rate (330,000 to 525,000 seeds acre^{-1}) in wider rows. Young et al. (2014) mention low soil moisture at time of planting and the inability to plant deep enough to reach moisture likely contributing to low establishment. At our environments, there was moisture prior to planting; however, moisture was somewhat limited after planting. This may have also contributed to low establishment in our research. Wysocki et al. (2009) used an open-pollinated cultivar in their study and observed a decrease in fall establishment in row spacing greater than 24-in. In general, similar results have been observed in literature where fall establishment decreased in wide rows and increased with increasing seeding rate.

Spring stands

Spring stands are a measurement of the quantity of fall-established plants that remain after winter. At the Manhattan environment, there was no genotype x seeding rate interaction for spring stands. However, there were significant genotype and seeding rate effects (Table 3.2). Mercedes (HYB) and DKW44-10 (OP) having the greatest spring stands, and Riley (OP) had the least (Figure

3.6a). Spring stands increased as seeding rate increased for all genotypes (Figure 3.6b). At the Hutchinson environment, where residue was not tilled, there was an interaction between genotype and seeding rate that was captured by the type (HYB and OP) x seeding rate response (Table 3.3), indicating a differential response to seeding rate by the two types of cultivars. Both hybrid and open pollinated cultivars increased linearly as seeding rate increased, but while the hybrid regression line had a less steep response (Figure 3.7). For the open-pollinated cultivars, spring stand for the greatest two seeding rates were greater than all others. The hybrid response to seeding rate was increasing spring stands with increasing seeding rate. The Hutchinson environment where residue was vertically tilled also had a significant genotype x seeding rate interaction that could be described by a type x seeding rate interaction (Table 3.4). Spring stands of the open-pollinated cultivars tended to decrease as seeding rate increased (Figure 3.8), -but hybrid spring stands were no different at seeding rates greater than 100,000 seeds acre^{-1}. In general, hybrid and open-pollinated cultivars had similar responses to seeding rate, as seeding rate increased so did spring stands. A correlation analysis across environments showed that fall establishment and spring stands were positively correlated ($r = 0.73$, $P = <0.001$), where fall establishment increased with increasing seeding rate in the fall and stands followed a similar pattern in the spring.

Spring plant densities are a function of fall plant densities and winter survival (Young et al., 2014). Many researchers report post-winter final stands in terms of winter survival. This is an important way to interpret results, which involves comparing the number of plants established in the fall to the final count in the spring. However, this could be misleading if fall establishment started out very high. Therefore, it is also important to consider final population in the spring. Young et al. (2014) suggests that excellent yields (>30 bu acre^{-1}) were obtained from plant densities of 86,000 to 174,000 plants acre^{-1}. In our set of experiments, spring stands ranged from

31,000 to 85,000 plants acre^{-1}. Young et al. (2014) reported spring stands ranging from 23,000 to 182,000 plants acre^{-1} across their set of experiments and saw spring densities increasing with increasing seeding rates, which can be seen in this study as well.

Winter survival

Winter survival is calculated as a percent of fall plants that remain post-winter and gives perspective to the amount of plants that contribute to yield. At the Manhattan environment, there was no genotype x seeding rate interaction, indicating that cultivars had a similar response to seeding rate (Table 3.2). Genotype was not significant, however seeding rate had an impact on winter survival. Winter survival decreased as seeding rate increased (Figure 3.9). At Hutchinson where residue was not tilled, there was a significant genotype x seeding rate interaction that was generated by the hybrids responding differently from each other to seeding rate (Table 3.3, Figure 3.10). However, the winter survival of each hybrid did not differ from open-pollinated cultivars. The regression of Safran (HYB) and the open-pollinated cultivars indicates that winter survival decreases with increasing seeding rate, while Mercedes (HYB) showed less response to seeding rate. At the Hutchinson environment where residue was vertically tilled, there was no genotype x seeding rate interaction and none of the treatment factors affected winter survival (Table 3.4, Figure 3.11). At the two environments were genotype x seeding rate interactions occurred, in general winter, survival decreased with increasing seeding rate. A correlation analysis across all environments revealed that fall establishment and winter survival are negatively correlated ($r = -0.63$, $P = < 0.001$), supporting the observation that winter survival was greater where establishment was less in the fall. The net result of reduced winter survival for greater seeding rates is that spring stands tended to be less variable across seeding rates.

Many producers and researchers' express difficulties of establishing a winter canola stand. However, one of the more significant challenges surrounding winter canola production is winter survival (Holman et al., 2011). Young et al. (2013) reported greatest winter survival values, 78 to 100%, with seeding rates of 200,000 to 400,000 seeds acre^{-1}. Assefa et al. (2014) reported winter survival values ranging from 69 to 89% depending on cultivar. Winter survival for our study ranged from 88 to 46%. Lower establishment in Young et al. (2014) experiment resulted in superior winter survival as well as greater yields. Environmental factors play a large role in winter survival and are not limited to cold temperatures; moisture also plays a role in winter loss. In our experiment, temperatures were mild, not dropping into single digits until well into January, however moisture was limited over winter. This could have contributed to some winter loss in our study. In addition, there are many management factors that can play a role in winter survival. Studies have found that winter survival improved with tillage (Peeper et al., 2007, Schillinger, 2010). Another way to manage residue is widening row spacing and moving more residue between rows, with that said there were no row spacing comparisons in this study however the experiment was planted in 30-in rows. Canola planted 30-in rows can experience greater plant-to-plant competition if planted in higher seeding rates.

Bloom progression

Bloom progression can be a useful method to understand how treatments influence the duration and uniformity of the reproductive growth stage. At the Manhattan environment, there was no genotype x seeding rate interaction, indicating there was no differential response to seeding rate and no genotype response (Table 3.2). However, there was a seeding rate response at 250,000 seeds acre^{-1} where bloom progression was greatest and all other seeding rate treatments were less (Figure 3.12). There was a significant genotype x seeding rate interaction generated by a hybrid x seeing rate interaction at Hutchinson where residue was not tilled (Table 3.3). Mercedes (HYB) bloom progression increased with increasing seeding rate, however to the response was most evident at the greatest seeding rates (Figure 3.13). The hybrid and the open-pollinated cultivars behaved similarly in response to seeding rate the regression indicates that they decreased with increasing seeding rates, while Mercedes (HYB) increased as seeding rate increased. At Hutchinson where residue was vertically tilled, there was no genotype x seeding rate interaction (Table 3.4). However, there was a seeding rate effect for bloom progression regardless of genotype (Table 3.4). Bloom progression was greatest at 100,000 to 250,000 seeds acre^{-1}, and least at 325,000 seeds acre^{-1} (Figure 3.14). At two of the three environments, seeding rate influenced bloom progression, however the response was not consistent.

This information can be useful when considering uniformity of pods as harvest approaches. Canola will flower on the main raceme for up to 4 weeks under normal growing conditions (Stamm et al., 2012). Seeding rate could potentially influence bloom progression because as stands decrease, plant-to-plant competition could decrease allowing plants to branch. If plants have a considerable amount of branching, pushing bloom progression longer this could potentially cause less pod uniformity. In our study results indicated that this was not the case.

Yield

Treatment factors in our experiment had little impact on yield. The interaction between genotype and seeding rate did not significantly affect yield at any environment in this set of experiments (Tables 3.2, 3.3, and 3.4). Only at the Manhattan environment, was there a significant influence of genotype on yield, while seeding rate did not significantly affect yield at any of the environments. Riley (OP), Safran (HYB), and Mercedes (HYB) were no different in terms of yield, ranging from 17.7 to 19.8 bu acre^{-1}. The least yielding cultivar was DKW44-10 (OP), at

13.5 bu acre^{-1}. At the Manhattan environment, yield averaged 16 bu acre^{-1} across treatments, which was considerably less than the other two environments: 25 bu acre^{-1} in the Hutchinson no-till environment and 30 bu acre^{-1} in the Hutchinson vertical tillage environment. Plants in the Manhattan environment experienced a late season frost that terminated early blooms on the main raceme. Assefa et al. (2014) reported that environment was responsible for explaining 73% of variability in canola yield. The weather events in the Manhattan environment could have contributed to low yields. Assefa et al. (2014) looked at weather conditions associated with yield extremes and suggested that canola yields were maximized when rainfall was relatively low during establishment, but was greater from December through June. In our study, all environments experienced relatively low rainfall December through April, not experiencing significant rain fall events until early May. This may have played a significant role in the below to average yields reported from our study. However, yields were consistent with research done in 30-in rows by Wysocki et al. (2009), where no differences were found in 30-in rows between 375,000 and 525,000 seeds acre^{-1} rates during either year of the study. In our study, seeding rate had no effect on yield at any of the environments. During the first and more water-limited year of the study performed by Wysocki et al. (2009) yields averaged 33 bu acre^{-1}, rainfall increased during the second year of the study, in response yields increased to 48 bu acre^{-1}. Genotype impacted yield at one environment where all other genotypes out performed DKW44-10 and seeding rate did not impact yield at any environment. Correlation analysis revealed no significant relationships between yield and measures of plant density and survival.

Percent oil

Differences in oil concentration between treatment factors were not large, and treatments had a significant effect on oil concentration in only one environments. At the Manhattan environment, there was no genotype x seeding rate interaction, however, genotype and seeding rate both influenced oil content (Table 3.2). The hybrids and Riley (OP) behaved similarly for oil concentration and DKW44-10 (OP) produced least of all genotypes (Figure 3.18a). For seeding rate effects 175,000 and 325,000 seeds acre^{-1} were no different and 325,000 seeds acre^{-1} was no different than the remaining seeding rates having no consistent separation in terms of seeding rate treatments. In general, differences between seeding rates were not large, however 175,000 seeds acre^{-1} produced slightly greater oil concentrations than the remaining seeding rates. At both Hutchinson environments, there were no genotype x seeding rate effect or main effect differences that influenced oil concentration (Tables 3.3 and 3.4). Oil contents at the two Hutchinson environments ranged from 35 to 39% (Figures 3.19 and 3.20). The small differences between treatments at the Manhattan environment make it difficult to say whether it would be advantageous to increase or decrease seeding rates in relation to genotype with respect to how it might affect oil concentration. Assefa et al. (2014) reported oil concentration ranges from 30 to 47% of seed weight. The values from our study were well within this reported range. They also reported that nearly 80% of variation in oil content could be explained by environment and variation explained by genetics was comparatively very small. Treatments did not have a large impact on oil concentration, and results from our experiment were consistent with results found in literature.

Conclusions

The purpose of this experiment was to determine the effects of seeding rate on performance of open pollinated and hybrid cultivars in 30-in rows on stand establishment, winter survival, yield and oil content. We hypothesized that hybrids should emerge more quickly, resulting in increased fall growth at lower seeding rates. Therefore, optimum seeding rates for open pollinated and hybrid cultivars in 30-in rows will be different. Genotype response to seeding rate for fall establishment resulted in a varied response rather than a hybrid versus open-pollinated response. In general, hybrid and open-pollinated cultivars had similar responses to seeding rate, as seeding rate increased so did spring stands. A genotype x seeding rate response did not occur at every environment, however in general winter survival decreased with increasing seeding rate, indicating that winter survival may increase at lower populations. Results were not consistent for seeding rate influence on bloom progression. If plants have a considerable amount of branching, pushing bloom progression longer could potentially cause less pod uniformity. In our study results indicated that this was not the case. In our study, there was no optimal seeding rate effects for open-pollinated or hybrid cultivars that resulted in a yield differential. Both hybrid and open-pollinated winter canola cultivars responded similarly to seeding rate in 30-in rows in these experiments, indicating that similar seeding rates could be used for each type of cultivar.

References

Assefa, Y., K. Roozeboom, and M. Stamm. 2014. Winter canola yield and survival as a function of environment, genetics, and management. Crop Sci. 54:2303-2313.

Brandt, S.A., S.S. Malhi, D. Ulrich, G.P. Lafond, H.R. Kutcher, and A.M. Johnson. 2007. Seeding rate, fertilizer level, and disease management effects on hybrid versus open pollinated canola. Can. J. Plant Sci. 87:255-266.

Geier, H. 2004. Canola quality in Alaska. Research Progress Report 42. Ag. and For. Exp. Sta., Univ. of Alaska, Fairbanks.

Holman, J., S. Maxwell, M. Stamm, K. Martin. 2011. Effects of planting date and tillage on winter canola. Online. Crop Management doi:10.1094/CM-2011-0324-01-RS.

Jiang, H., L. Zhu, J. Dai, T. Song, Y. Yan, S. Chen. 2005. Analysis of protein, starch and oil content of single intact kernels by near infrared reflectance spectroscopy (NIRS) in maize (*Zea mays* L.). J. Plant Breeding, Blackwell Verlag, Berlin. Doi: 10.111/j.1439-0523.2007.01338. x.

Kansas State University. 2014. National Winter Canola Variety Trial Reports of Progress 1116. Agric. Exp. Stn. and Coop. Ext. Serv. Kansas State Univ., Manhattan.

Peeper, T., and M. Boyles. 2007. Winter Canola establishment and survival under three tillage systems. Online. Research results, Oklahoma State Univ. Ext., Stillwater, OK.

Schillinger, W.F., D.L. Young, A.C. Kennedy, and T.C. Paulitz, 2010. Diverse no-till irrigated crop rotations instead of burning and plowing continuous wheat. Field Crop Res. 115 39-49.

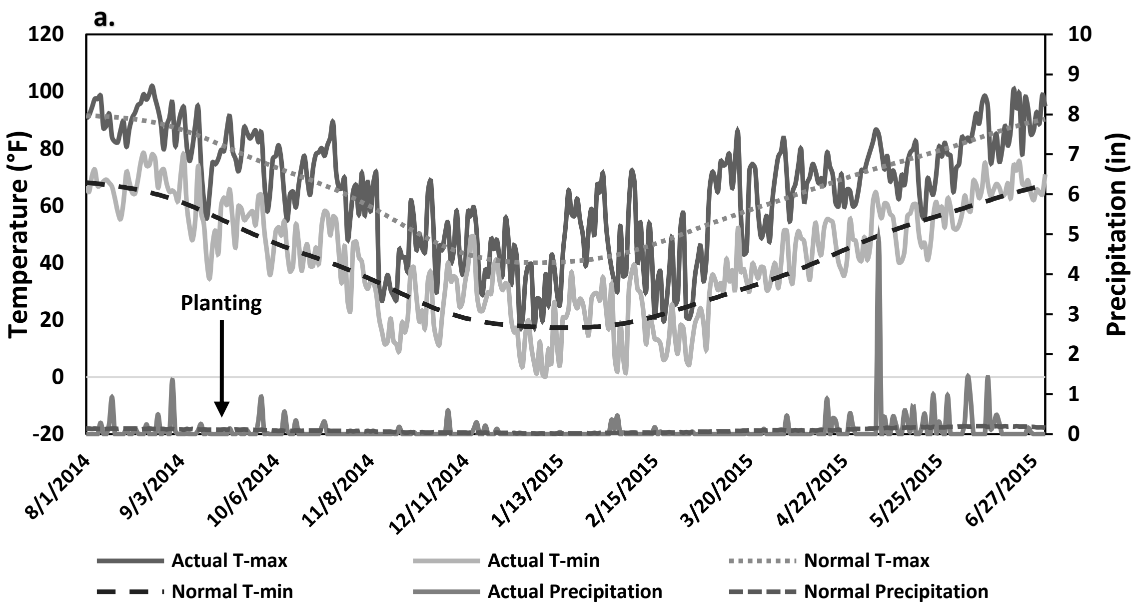
United States Climate Data. 2016. Programming and Design by Your Weather Service. [Online]. http://www.usclimatedata.com/.

United States Department of Agriculture. 2016. Natural Resources Conservation Service Web Soil Survey. [Online]. http://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm.

Wysocki, D., N. Sirovatka. 2009. Growing Canola on Wide Row Spacing. Oregon Agric. Exp. Station Spec Rep 879:50-55.

Young, F.L., W.L. Whaley, R. Pan, D. Roe, J.R. Alldredge. 2014. Introducing Winter Canola to the Winter Wheat-Fallow Region of the Pacific Northwest. Crop Mange. Dio:10.2134/CM-2013-0023-RS.

Figures



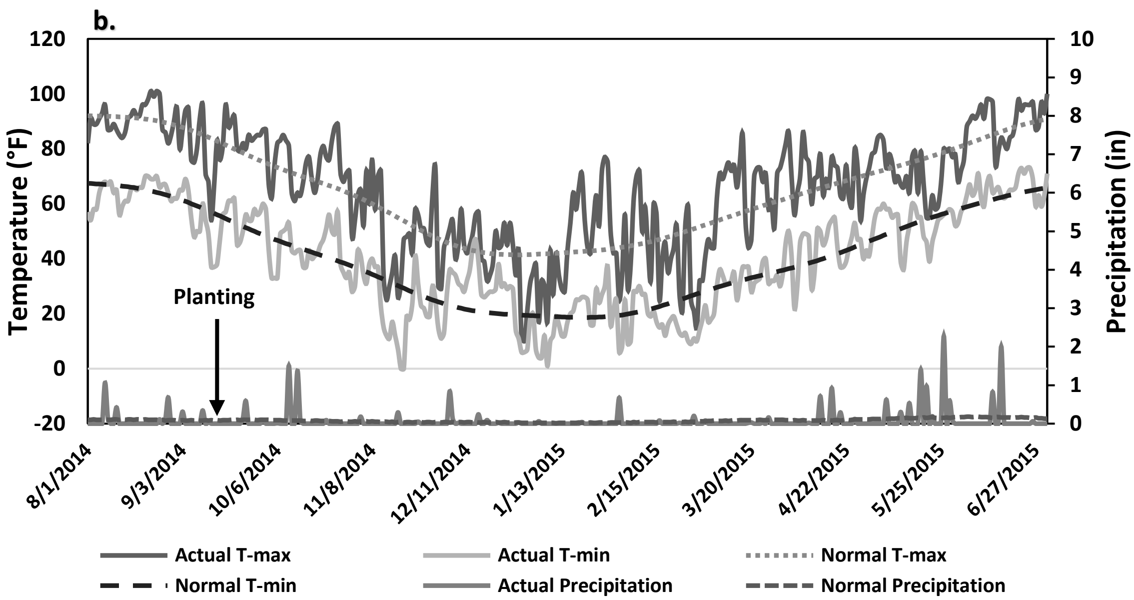


Figure 3.1. Temperatures and precipitation for Manhattan, KS (a) and Hutchinson, KS (b) for the 2014-15 growing season.

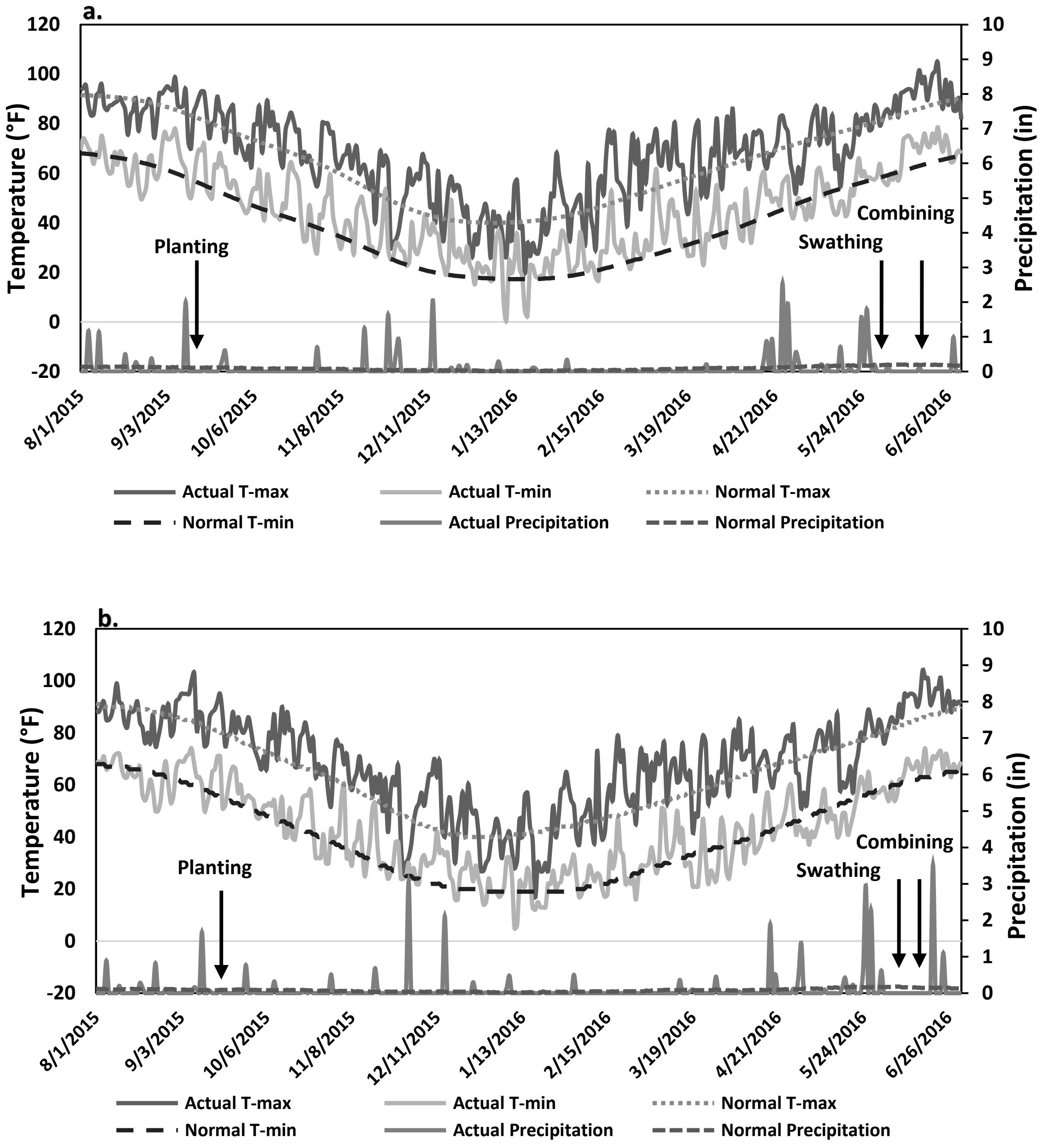


Figure 3.2. Temperatures and precipitation for Manhattan, KS (a) and Hutchinson, KS (b) for the 2015-16 growing season.

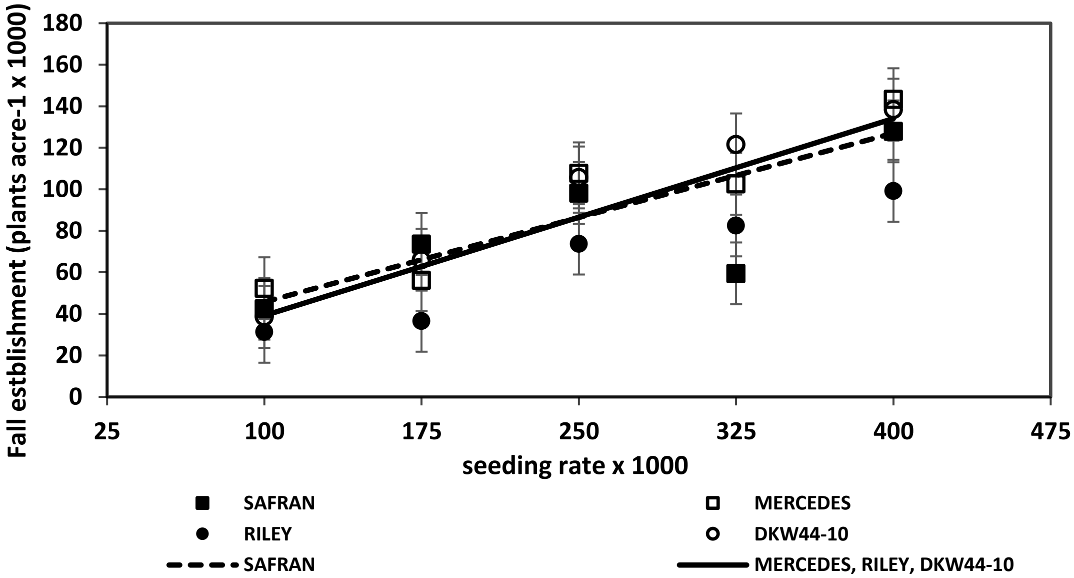
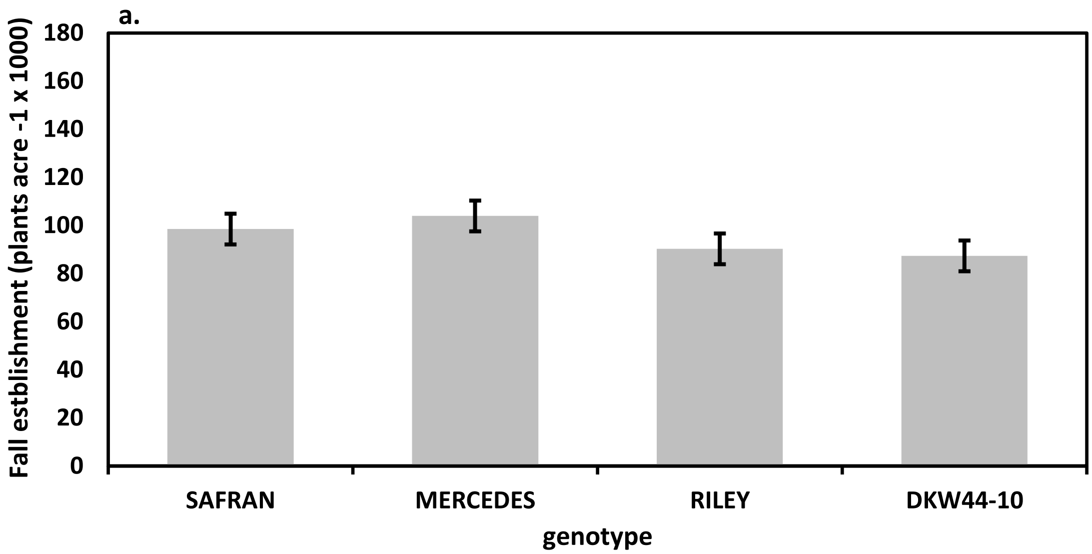


Figure 3.3. Fall establishment of four genotypes at five seeding rates planted in 30-inch rows where residue was not tilled, Manhattan, KS 2015-16; regression lines represent significant models and resulting from groupings of genotype, type, or some combination of the two as determined by the sequential ANOVA.



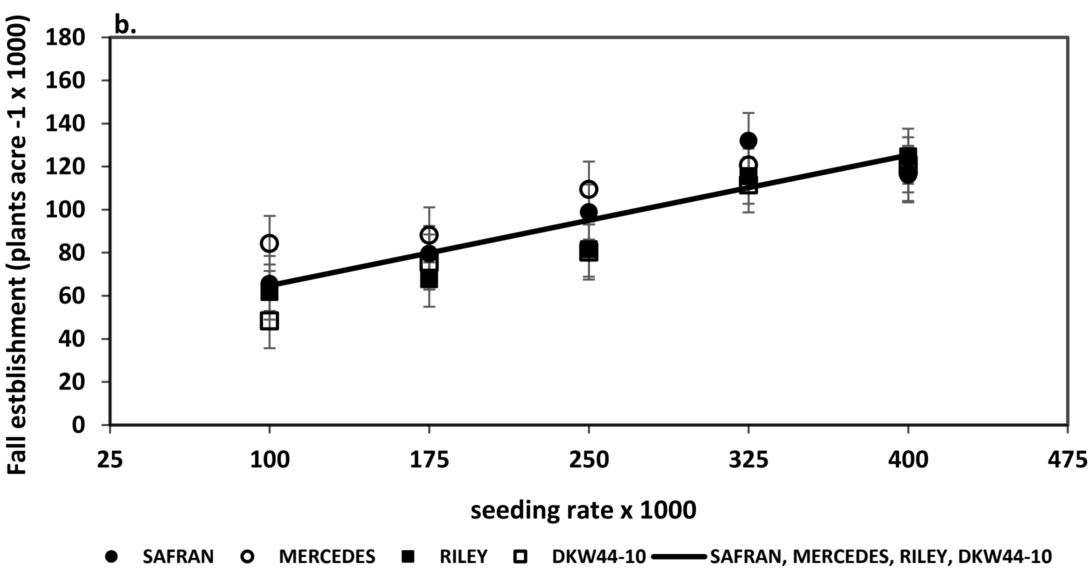


Figure 3.4. Fall establishment of four genotypes averaged over five seeding rates (a) and five seeding rates (b) planted in 30-inch rows where residue was not tilled, Hutchinson, KS 2015-16; regression lines represent significant models and resulting from groupings of genotype, type, or some combination of the two as determined by the sequential ANOVA.

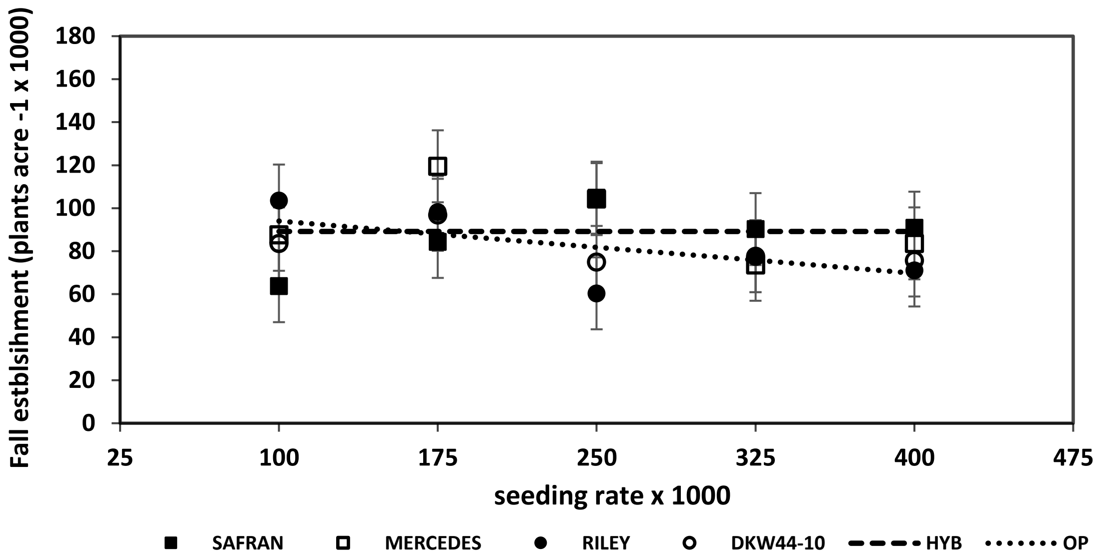


Figure 3.5. Fall establishment of four genotypes at five seeding rates planted in 30-inch rows where residue was vertically tilled, Hutchinson, KS 2015-16; regression lines represent significant models and resulting from groupings of genotype, type, or some combination of the two as determined by the sequential ANOVA.

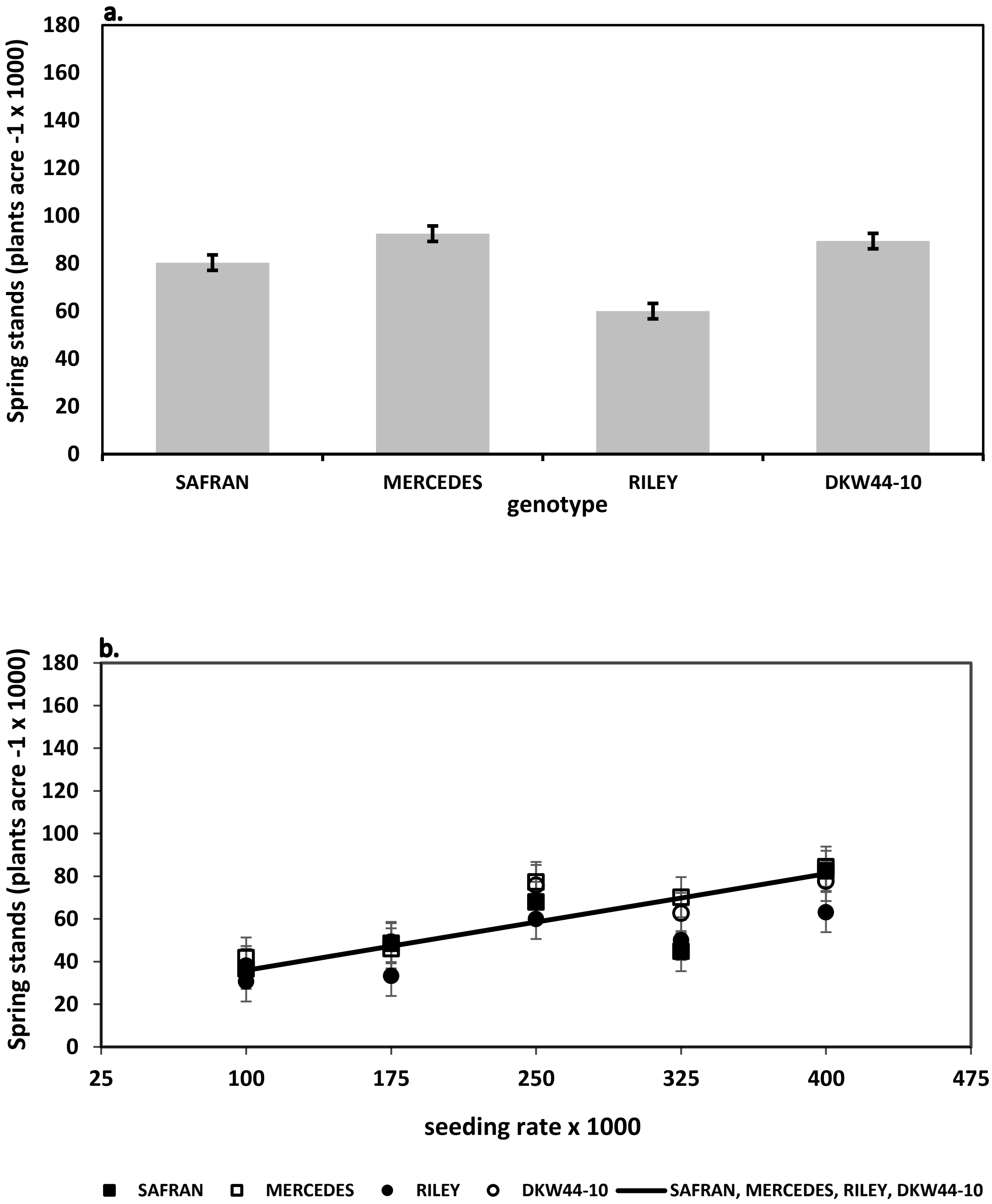


Figure 3.6. Spring stands of four genotypes averaged over five seeding rates (a) and five seeding rates (b) planted in 30-inch rows where residue was not tilled, Manhattan, KS 2015-16; regression lines represent significant models and resulting from groupings of genotype, type, or some combination of the two as determined by the sequential ANOVA.

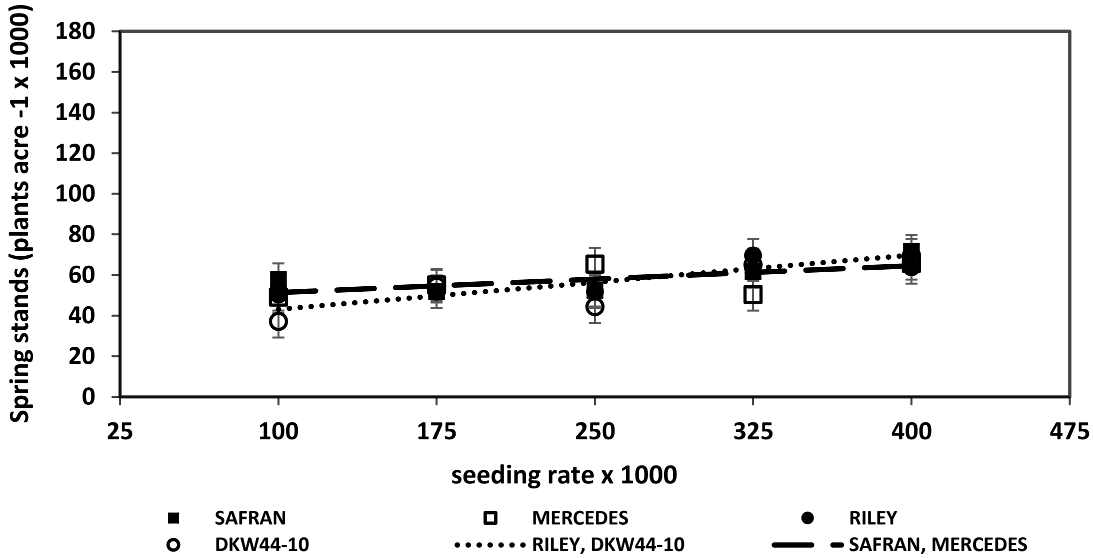


Figure 3.7. Spring stands of four genotypes at five seeding rates planted in 30-inch rows where residue was not tilled, Hutchinson, KS 2015-16; regression lines represent significant models and resulting from groupings of genotype, type, or some combination of the two as determined by the sequential ANOVA.

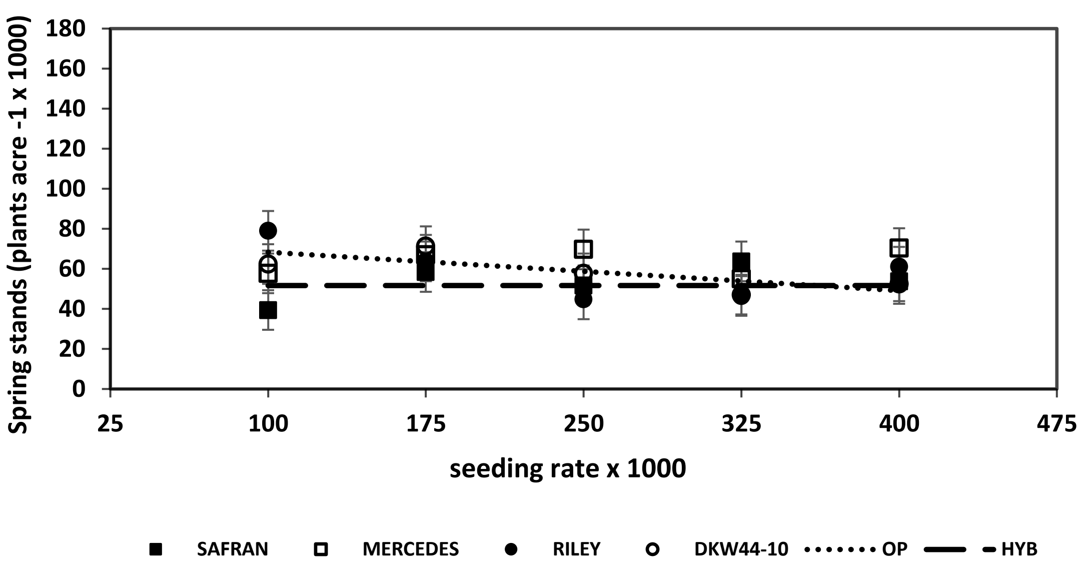


Figure 3.8. Spring stands of four genotypes at five seeding rates planted in 30-inch rows where residue was vertically tilled Hutchinson, KS 2015-16; regression lines represent significant models and resulting from groupings of genotype, type, or some combination of the two as determined by the sequential ANOVA.

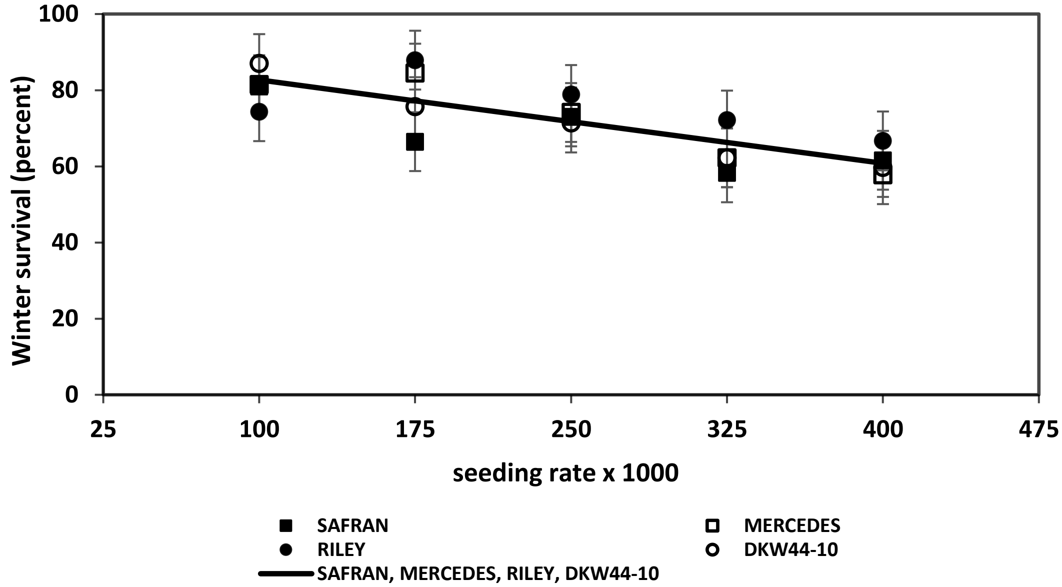


Figure 3.9. Winter survival of four genotypes at five seeding rates planted in 30-inch rows where residue was not tilled, Manhattan, KS 2015-16; regression lines represent significant models and resulting from groupings of genotype, type, or some combination of the two as determined by the sequential ANOVA.

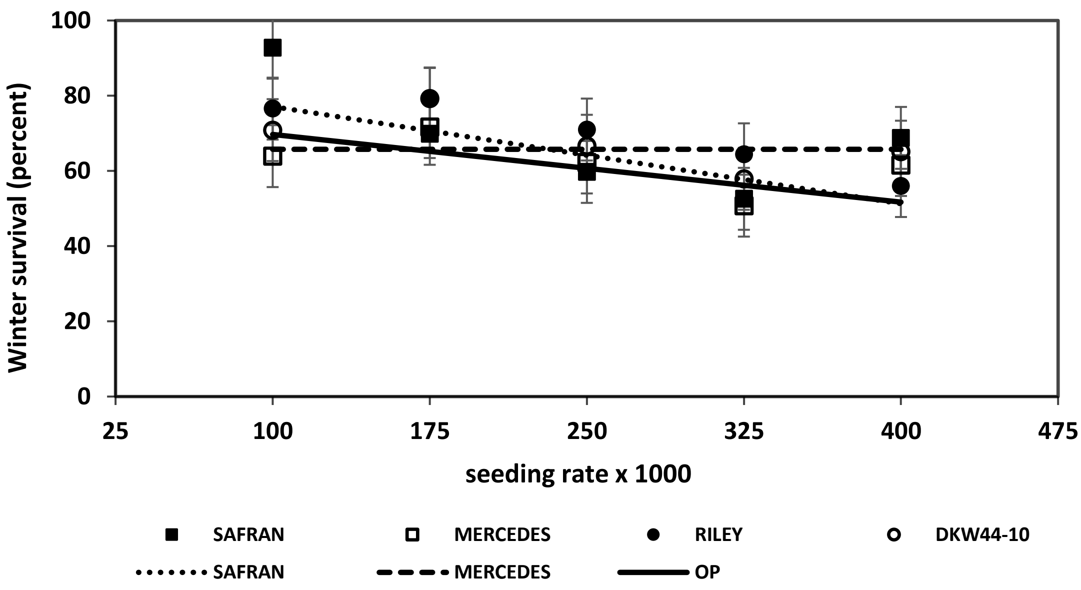


Figure 3.10. Winter survival of four genotypes at five seeding rates planted in 30-inch rows where residue was not tilled, Hutchinson, KS 2015-16; regression lines represent significant models and resulting from groupings of genotype, type, or some combination of the two as determined by the sequential ANOVA.

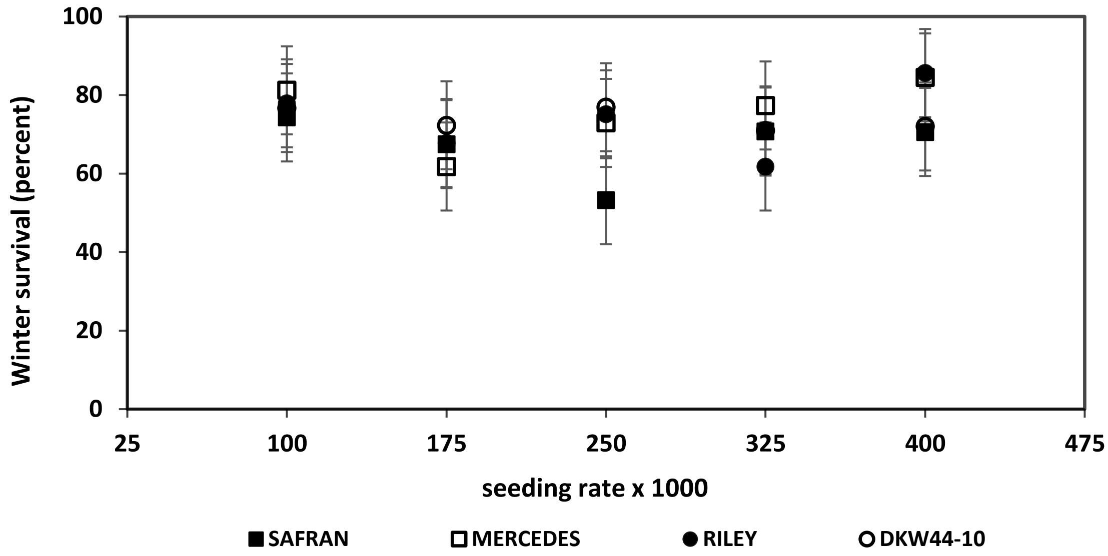


Figure 3.11. Winter survival of four genotypes at five seeding rates planted in 30-inch rows where residue was vertically tilled, Hutchinson, KS 2015-16; regression lines represent significant models and resulting from groupings of genotype, type, or some combination of the two as determined by the sequential ANOVA.

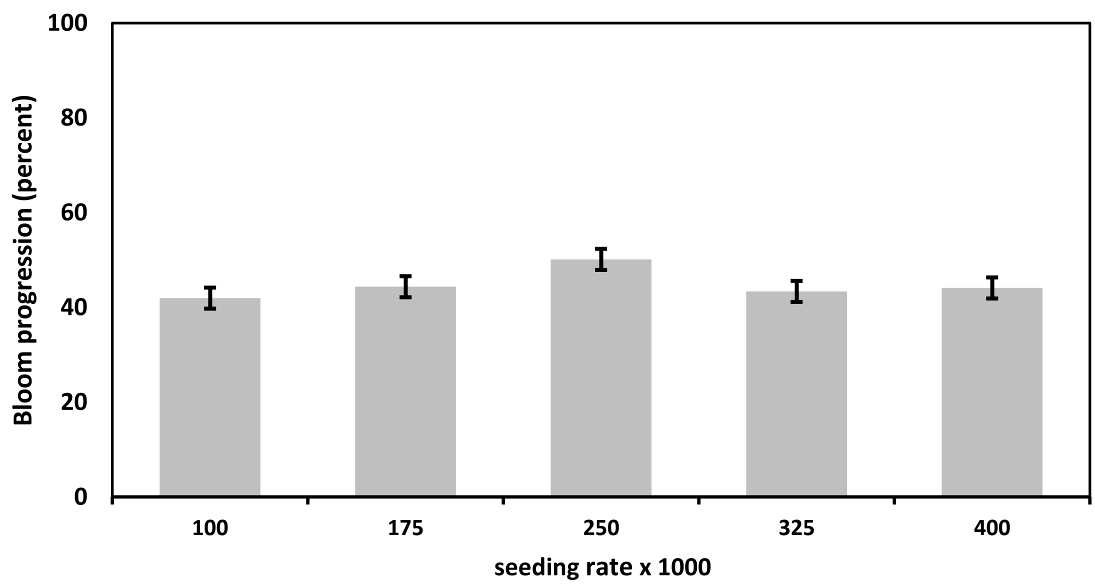


Figure 3.12. Bloom progression at five seeding rates averaged over four genotypes planted in 30-inch rows where residue was not tilled, Manhattan, KS 2015-16.

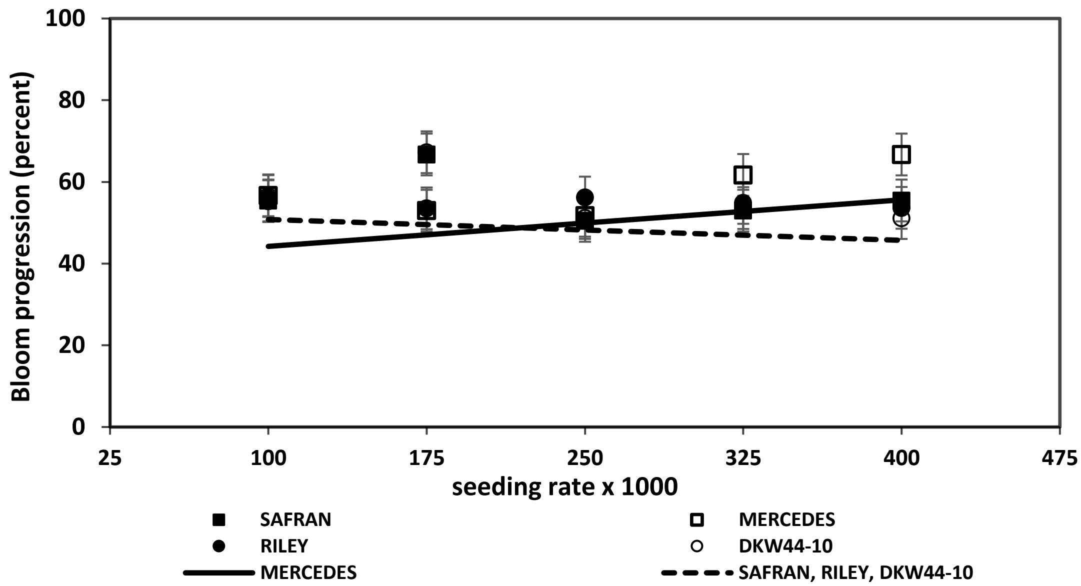


Figure 3.13. Bloom progression of four genotypes at five seeding rates planted in 30-inch rows where residue was not tilled, Hutchinson, 2015-16; regression lines represent significant models and resulting from groupings of genotype, type, or some combination of the two as determined by the sequential ANOVA.

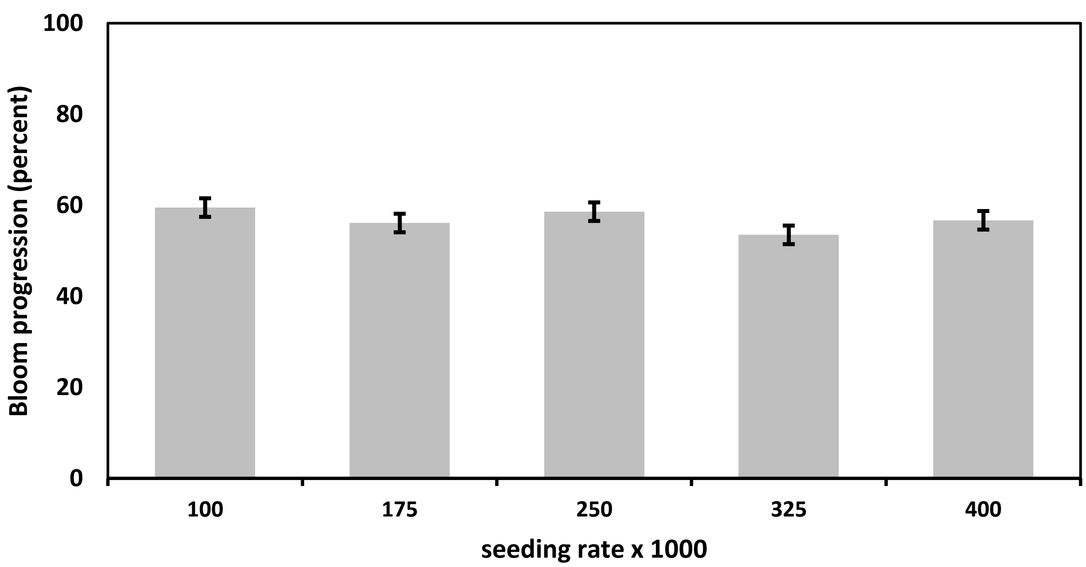


Figure 3.14. Bloom progression at five seeding rates averaged over four genotypes planted in 30-inch rows where residue was vertically tilled Hutchinson 2015-16.

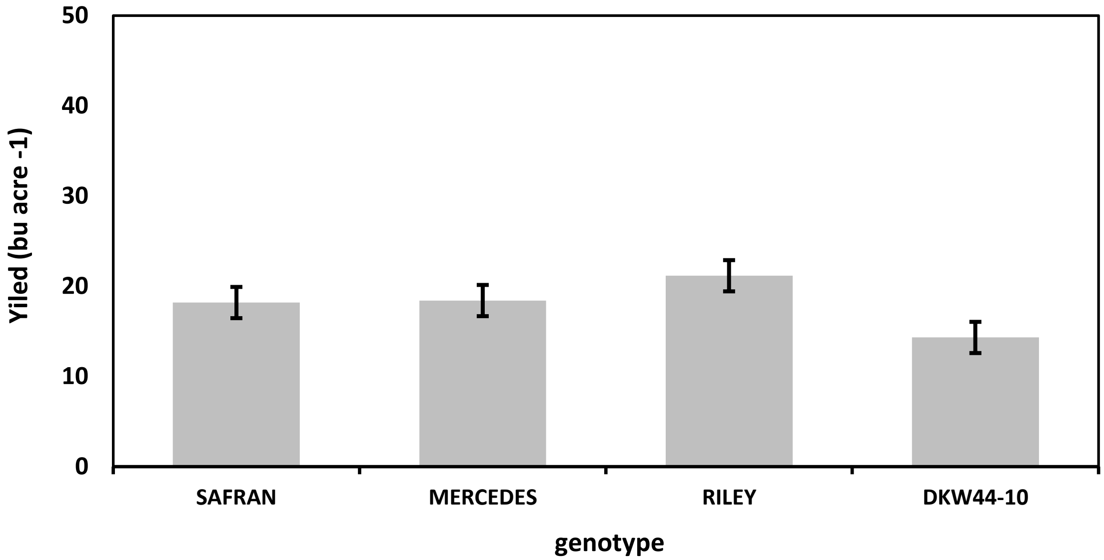


Figure 3.15. Yield of four genotypes averaged over five seeding rates planted in 30-inch rows where residue was not tilled, Manhattan, KS 2015-16.

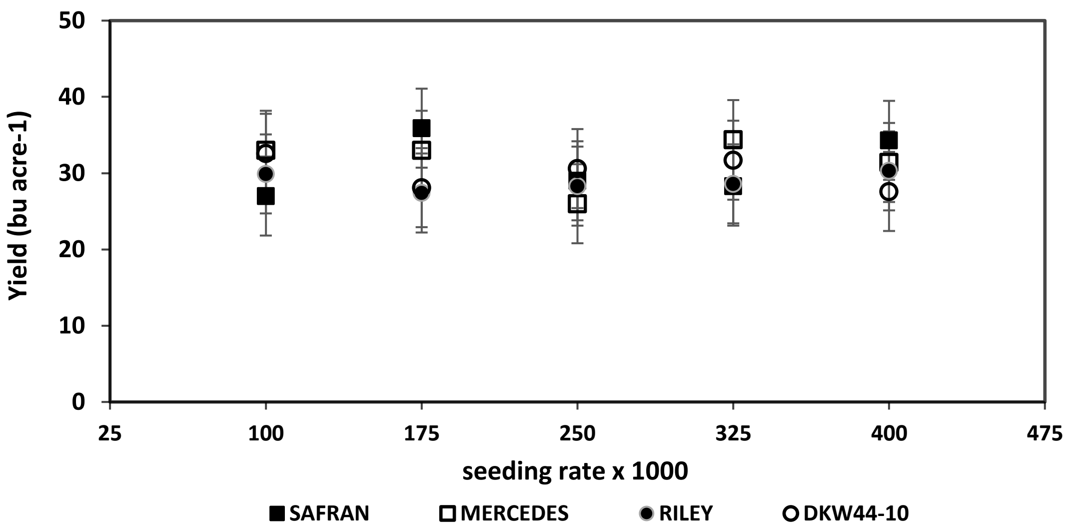


Figure 3.16. Yield of four genotypes at five seeding rates planted in 30-inch rows where residue was not tilled, Hutchinson, KS 2015-16; regression lines represent significant models and resulting from groupings of genotype, type, or some combination of the two as determined by the sequential ANOVA.

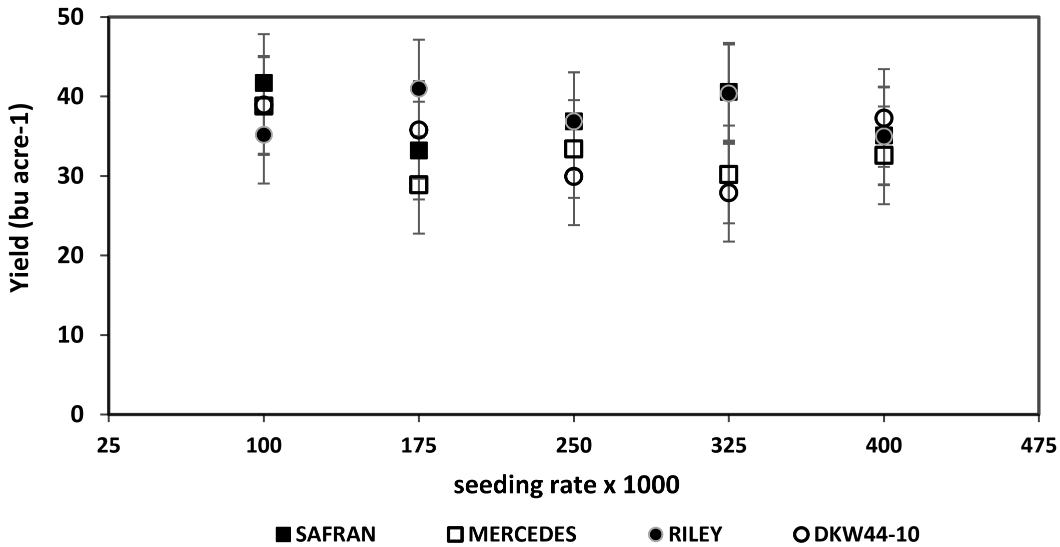


Figure 3.17. Yield of four genotypes at five seeding rates planted in 30-inch rows where residue was vertically tilled Hutchinson, KS 2015-16; regression lines represent significant models and resulting from groupings of genotype, type, or some combination of the two as determined by the sequential ANOVA.

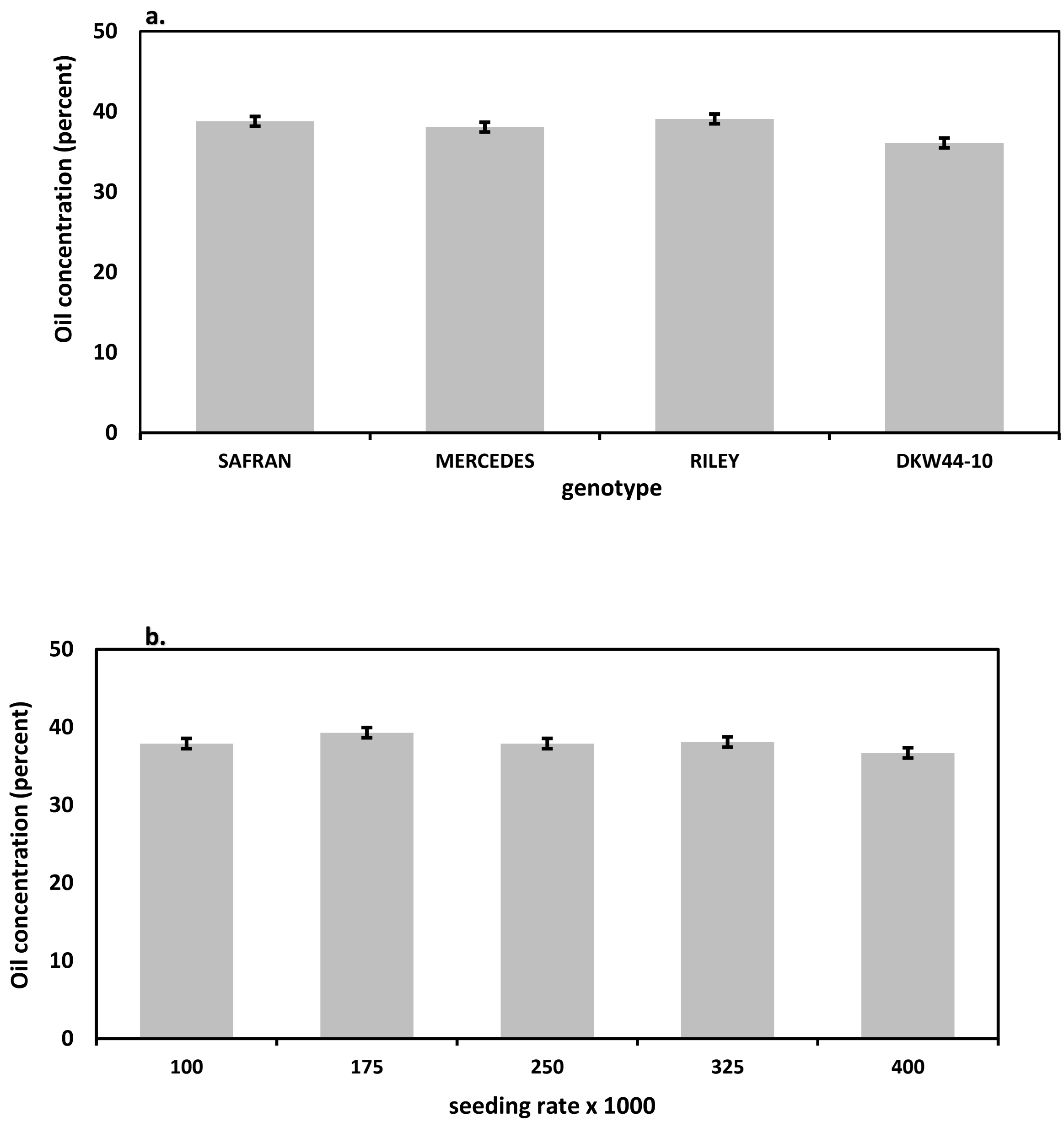


Figure 3.18. Oil percent of four genotypes averaged over five seeding rates (a) and five seeding rates averaged over four genotypes (b) planted in 30-inch rows where residue was not tilled, Manhattan, KS 2015-16.

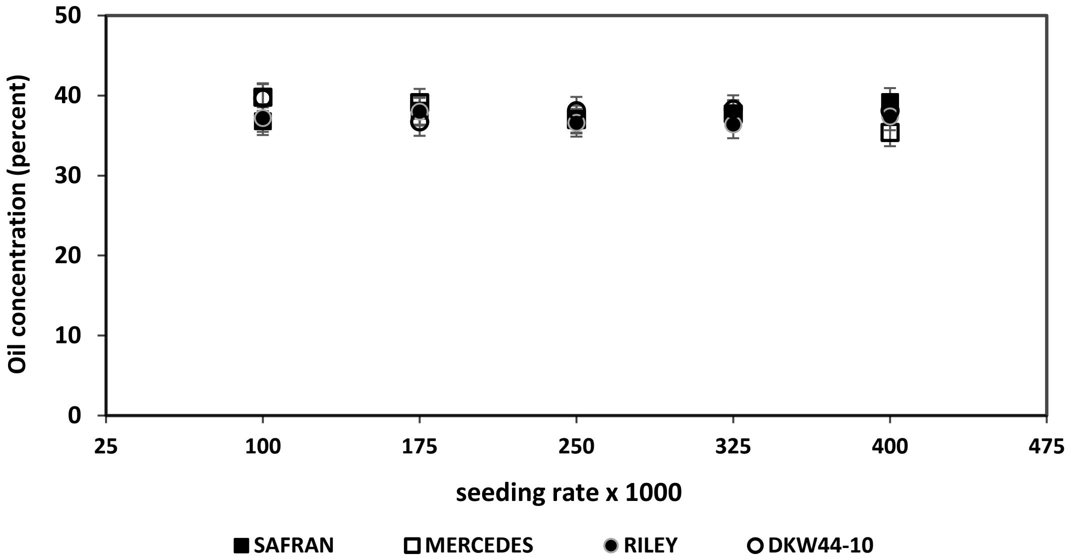


Figure 3.19. Oil percent of four genotypes at five seeding rates planted in 30-inch rows where residue was not tilled, Hutchinson, KS 2015-16; regression lines represent significant models and resulting from groupings of genotype, type, or some combination of the two as determined by the sequential ANOVA.

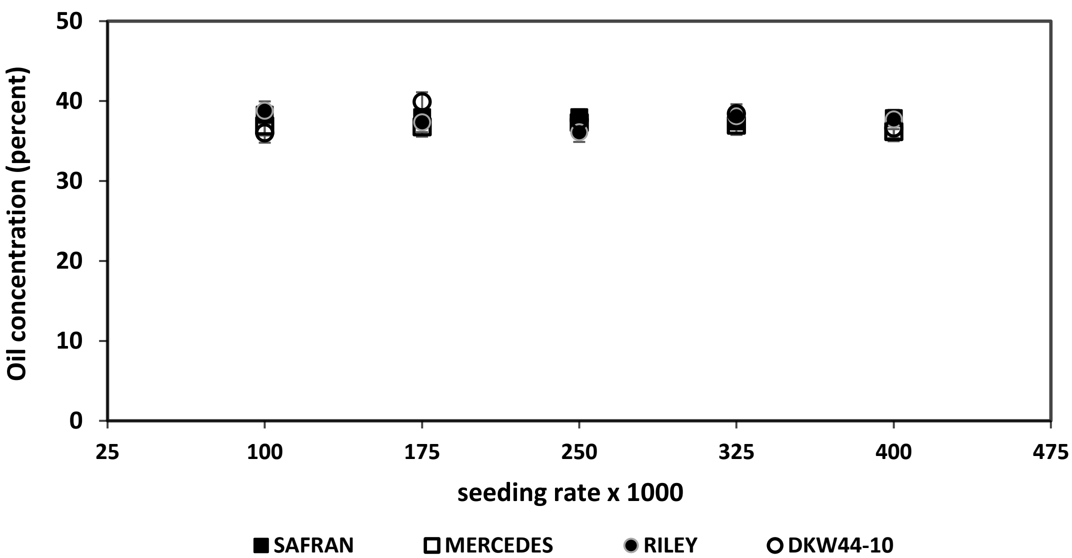


Figure 3.20. Oil percent of four genotypes at five seeding rates planted in 30-inch rows where residue was vertically tilled Hutchinson, KS 2015-16; regression lines represent significant models and resulting from groupings of genotype, type, or some combination of the two as determined by the sequential ANOVA.

Tables

Table 3.1. Coordinates, soil descriptions, and agronomic management for five Kansas environments where winter canola genotypes and seeding rates were evaluated in 2014-15 and 2015-16.

	Manhattan	**Hutchinson**
Coordinates	39.217874, -96.589686	37.928722, -98.029195
Tillage	No-till	No-till Vertical tillage
[†]Soil Series	Kahola silt loam	Ost loam
[†]Soil Classification	Fine silty, mixed, mesic Cumulic Hapludolls	Fine-loamy, mixed, superactive, mesic Udic Argiustolls
Fall Nitrogen	35 lb/A (32-0-0)	none
Fall Sulfur	20 lb/A (21-0-0-24)	none
Spring Nitrogen	100 lb/A (32-0-0)	75 lb/A (46-0-0)
Planting	September 13, 2014 September 18, 2015	September 15, 2014 September 14, 2015
Swathing	June 5, 2016	June 3, 2016
Harvest	June 12, 2016	June 9, 2016

[†]United States Department of Agriculture; Natural Resources Conservation Service Web Soil Survey.

Table 3.2. Significance of treatment and interaction effects of four genotypes at five seeding rates planted in 30-inch rows where residue was not tilled, Manhattan, KS 2015-16.

Variable	Genotype	Seeding rate	Genotype x seeding rate	Type[†] x seeding rate	OP x seeding rate	HYB x seeding rate
	p-Value					
Fall establishment	<0.0010	<0.0010	0.0119	0.4610	0.2547	0.0015
Spring stands	<0.0010	0.0003	0.4337	0.6395	0.0840	0.8964
Winter survival	0.1585	<0.0001	0.4433	0.8829	0.1616	0.3692
Bloom %	0.4748	0.0081	0.9034	0.8541	0.6893	0.6478
Yield	0.0015	0.8000	0.3793	0.2736	0.7965	0.4756
Oil %	0.0008	0.0413	0.1568	0.2292	0.3051	0.2700

[†] Type indicates grouping of genotypes into open-pollinated (OP) and hybrid (HYB) cultivars.

Table 3.3. Significance of treatment and interaction effects of four genotypes at five seeding rates planted in 30-inch rows where residue was not tilled, Hutchinson, KS 2015-16.

Variable	Genotype	Seeding rate	Genotype x seeding rate	Type† x seeding rate	OP x seeding rate	HYB x seeding rate
	p-Value					
Fall establishment	0.0166	<0.0010	0.5361	0.1648	0.5150	0.8526
Spring stands	0.0166	<0.0001	0.0972	0.0526	0.1934	0.2438
Winter survival	0.0155	0.1487	0.0881	0.1417	0.7193	0.0206
Bloom %	0.7800	0.5280	0.0107	0.2414	0.1489	0.0087
Yield	0.6883	0.8454	0.7460	0.3463	0.9747	0.4623
Oil %	0.5809	0.6985	0.4443	0.8716	0.1250	0.5418

† Type indicates grouping of genotypes into open-pollinated (OP) and hybrid (HYB) cultivars.

Table 3.4. Significance of treatment and interaction effects of four genotypes at five seeding rates planted in 30-inch rows where residue was vertically tilled, Hutchinson, KS 2015-16.

Variable	Genotype	Seeding rate	Genotype x seeding rate	Type† x seeding rate	OP x seeding rate	HYB x seeding rate
	p-Value					
Fall establishment	0.3495	0.1201	0.0759	0.0281	0.2707	0.5361
Spring stands	0.1142	0.1511	0.0093	0.0056	0.2020	0.4743
Winter survival	0.3492	0.1702	0.6747	0.4295	0.6105	0.5924
Bloom %	0.5475	0.0468	0.1291	0.1817	0.2946	0.1727
Yield	0.1925	0.6106	0.6411	0.4396	0.4366	0.8365
Oil %	0.5018	0.8443	0.7413	0.6804	0.3257	0.9794

† Type indicates grouping of genotypes into open-pollinated (OP) and hybrid (HYB) cultivars.

Table 3.5. Estimated regression and model fit parameters for establishment, survival and yield of response of canola genotypes to five seeding rates planted in 30-inch rows where residue was not tilled at Manhattan, KS 2015-16.

Response parameter and genotypes	Model	Intercept	Slope	RMSE	R^2	Pr > F
Fall establishment		plants acre^{-1}				
Safran	linear	18.6	0.27	27.1	0.54	< 0.0001
Mercedes, Riley, DKW44-10	linear	7.521	0.32	26.7	0.62	<0.0001
Spring stands		plants acre^{-1}				
Safran, Mercedes, Riley, DKW44-10	linear	20.8	0.15	16.6	0.48	<0.0001
Winter survival		percent				
Safran, Mercedes, Riley, DKW44-10	linear	90.0	-7.3×10^{-5}	15.5	0.19	<0.0001

Table 3.6. Estimated regression parameters and model fitness for establishment, survival and yield parameters of four genotypes at five seeding rates planted in 30-inch rows where residue was not tilled at Hutchinson, KS 2015-16.

Response parameter and genotypes	Line	Intercept	Slope	RMSE	R^2	Pr > F
Fall establishment				plants acre^{-1}		
Safran, Mercedes, Riley, DKW44-10	linear	44.6	0.20	26.4	0.39	<0.0001
Spring stands				plants acre^{-1}		
Safran, Mercedes (HYB)	linear	46.9	0.04	15.6	0.08	0.0089
Riley, DKW44-10 (OP)	linear	34.2	0.09	16.3	0.25	<0.0001
Winter survival				percent		
Safran	linear	85.7	-2.2×10^{-5}	15.4	0.27	0.0005
Mercedes	NS	37.4	7.2×10^{-7}	2.42	0.0010	0.8075
Riley, DKW44-10 (OP)	linear	86.7	-7.5×10^{-6}	17.5	0.17	0.0002
Bloom progression				percent		
Mercedes	linear	40.4	3.8×10^{5}	10.1	0.15	0.0872
Safran, Riley, DKW44-10	linear	52.5	9.6×10^{7}	7.9	0.05	0.0796

Table 3.7. Estimated regression parameters and model fitness for establishment, survival and yield parameters of four genotypes at five seeding rates planted in 30-inch rows where residue was tilled at Hutchinson, KS 2015-16.

Response parameter and genotypes	Line	Intercept	Slope	RMSE	R^2	Pr > F
Fall establishment				plants acre^{-1}		
Safran, Mercedes (HYB)	NS	89.2	0.004	39.1	0.0001	0.9148
Riley, DKW44-10 (OP)	linear	102.1	-0.08	28.5	0.08	0.0091
Spring stand				plants acre^{-1}		
Safran, Mercedes (HYB)	linear	51.7	0.02	19.3	0.03	0.1639
Riley, DKW44-10 (OP)	linear	74.7	-0.06	20.5	0.10	<0.0001
Bloom progression				percent		
Safran, Mercedes, Riley, DKW44-10	ns	53.8	-1.1×10^{-4}	6.7	0.03	0.1286

Chapter 4 - Research results and production implications

A growing interest in winter canola (Brassica napus L.) across the southern Great Plains has brought about issues regarding production, specifically residue management to improve winter survival in no-till production (Wysocki et al., 2009; Young et al., 2013). The success of direct seeding winter canola into wheat residue has received criticism in recent years due to extreme winter stand loss (Holman et al., 2011). If seed to soil contact is poor, the roots may not penetrate the soil surface and simply develop underneath the residue. Placing the seed too shallow and not penetrating the soil surface will result in a shallow rooted canola plant, and lengthening of the crown above the soil surface, making the plant susceptible to winter kill. To mitigate these effects, adequate seed to soil contact is important when directly seeding into undisturbed heavy residue (Holman et al., 2011). Moving residue and surface soil away from the row can mitigate the negative effects of residue coverage (Wysocki et al., 2009). An important decision in terms of agronomic practices for canola in no-till production includes how to manage residue left from the previous year's crop. There are various ways to help mitigate the effect of residue through either removal by burning or tillage, or by managing it with planting equipment. However, it is important to consider that residue is critical for moisture-limited dryland production systems; therefore, it can be advantageous to evaluate ways to manage it in terms of cleaning the seed row. The answer to a question that canola producers could benefit from knowing is; "can residue be managed in a way that allows them to utilize the benefits of residue while creating an optimal seed bed for winter canola?"

In addition to residue management decisions that growers must make, they also must consider agronomic practices such as seeding rate, row spacing, and genotype selection. All of these factors may have large effects on seed yield and oil quality (Kutcher et al., 2013). Wider rows have the potential to better prepare the seed row, potentially increasing stand establishment (Wysocki et al., 2009). Conversely, greater yields have been reported in narrow rows (Morrison et al., 1990, Wysocki et al., 2009); presumably due to less interplant competition that resulted in a greater number of pods per plant and seeds per pod. Taking the results mentioned above into consideration, it could be beneficial to reduce seeding rates in wide rows and still benefit from the residue management of this row spacing system. The objective of our on-farm experiment was to determine the effect of residue management, seeding rate, and row spacing on stand establishment, winter survival, and yield. A successful winter canola crop is achieved through the multifaceted interaction of genetics, environment, and management. Our research station experiment examined the effects of seeding rate on open-pollinated versus hybrid cultivars. Research suggests that hybrid canola is more vigorous growing in the fall, raising the question: can producers get by with lowering seeding rates for hybrid canola over open-pollinated cultivars and achieve similar yields, or are optimal seeding rates similar for both types of canola (McVetty, 1995).

Results collected from our series of research experiments indicate that management practices such as residue management, optimal row spacing and seeding rates can help improve winter canola production. Cooperator practice tended to produce the greatest fall establishment and spring plant stands, unless the AGCO seeding rate was greater than targeted (Andale site). At the other locations, cooperator seeding rates were as much as seven times greater that the lowest AGCO seeding rate treatments. It is important to note that increasing stands by as much as 50 to 100% or more in some cases did not translate into large yield differences. In general, winter survival tended to increase in response to lower seeding rates. The research experiments conducted on farm suggests that winter survival tended to increase as seeding rate decreased in 20-inch rows.

Reduced seeding rates in 20- and 30-in row spacings using the AGCO residue management system produced similar or superior yields than cooperator practice in all environments. Both hybrid and open-pollinated winter canola cultivars responded similarly to seeding rate in 30-in rows in these experiments, indicating that similar seeding rates could be used for each type of cultivar. Correlation analysis across all environments revealed that fall establishment and winter survival are negatively correlated, supporting that the observation that winter survival was greater where establishment was less in the fall. Management practices such as those researched in our study have the potential to benefit canola production.

What do these results mean for the bottom-line? Producers are most interested in successfully harvesting a profitable crop, with the best use of resources. The results from our on-farm row spacing comparisons suggest that narrower rows can offer some improvement in winter survival. Results also indicate that seeding rates can be reduced from those typically used by canola producers in high residue, no-till or reduced tillage systems if residue can be adequately removed from the seed row. In addition, similar seeding rates can be used for open-pollinated and hybrid cultivars. Management practices such as narrowing row spacing, reducing seeding rates, and adequately managing residue at planting may result in small improvements to establishment, winter survival, and consequently (if no other factors are limiting) improving final yields.

References

Holman, J., S. Maxwell, M. Stamm, K. Martin. 2011. Effects of planting date and tillage on winter canola. Online. Crop Manage. doi:10.1094/CM-2011-0324-01-RS.

Kutcher, H.R., T.K. Turkington, G.W. Clayton, and K.N. Harker. 2013. Response of herbicide-tolerant canola (*Brassica napus* L.) cultivars to four row spacings and three seeding rates in a no-till production system. Can. J. Plant Sci. 93:1229-1236.

Lofton, J., C.B. Godsey, and H. Zhang. 2010. Determining aluminum tolerance and critical soil pH for winter canola production for acidic soils in temperate regions. Agron. J. 102:327–332. doi:10.2134/agronj2009.0252.

McVetty, P.B.E. 1995. Review of performance and seed production of hybrid brassicas. Dept. Plant Sci. Univ. Manitoba, Winnipeg, MB, Canada.

Morrison, M.J., P.B.E. McVetty, and R. Scarth. 1990. Effect of row spacing and seeding rates on summer rape in southern Manitoba. Can. J. Plant Sci. 70:127-137.

Wysocki, D., N. Sirovatka. 2009. Growing Canola on Wide Row Spacing. Oregon Agric. Exp. Station Spec Rep 879:50-55.

Young, F.L., W.L. Whaley, R. Pan, D. Roe, J.R. Alldredge. 2013. Introducing Winter Canola to the Winter Wheat-Fallow Region of the Pacific Northwest. Crop Manage. Dio:10.2134/CM-2013-0023-RS.

Appendix A - SAS Codes: "The Effect of Residue Management, Row Spacing, and Seeding Rate on Winter Canola Establishment and Survival"

```
DM 'LOG; CLEAR; OUTPUT; CLEAR;'
OPTIONS PS = 5000 LS=120 NODATE;

TITLE '2014-2016 Canola AGCO On-farm ANOVA';

PROC IMPORT
  DATAFILE=;
  DBMS=XLSX
  OUT=RCB REPLACE;
  SHEET=;
  GETNAMES=YES;
RUN;

DATA RCB; SET RCB;
 *IF Location = "ANDALE" THEN DELETE;
 *IF Location = "STAFFORD" THEN DELETE;
 *IF Location = "KINGMAN" THEN DELETE;
 *IF Location = "CONWAY SPRINGS" THEN DELETE;
 *IF Location = "KIOWA" THEN DELETE;
 *DMkgha = DMLBPA * 1.12;
 *IF EQUIP = "FARMER" THEN DELETE;
RUN;

PROC SORT DATA=RCB; BY Location;
RUN;

PROC PRINT DATA=RCB;
RUN;

PROC GLIMMIX DATA=RCB; TITLE 'INCLUDING FARMER PRACTICE';
CLASS LOCATION TREATMENT BLOCK EQUIP ROW_SPACE_IN SR SUB_SAMPLE; BY LOCATION;
MODEL YIELD = TREATMENT/DDFM=SATTERTH;
RANDOM BLOCK SUB_SAMPLE;
LSMEANS TREATMENT/LINES ALPHA = 0.1;

RUN; QUIT;

PROC GLIMMIX DATA=RCB; TITLE 'AGCO ONLY';
CLASS LOCATION BLOCK EQUIP ROW_SPACE_IN SR SUB_SAMPLE; BY LOCATION;
MODEL YIELD = ROW_SPACE_IN SR ROW_SPACE_IN*SR/DDFM=SATTERTH;
RANDOM BLOCK SUB_SAMPLE;
LSMEANS ROW_SPACE_IN/LINES;
LSMEANS SR/LINES;
LSMEANS ROW_SPACE_IN*SR/LINES ALPHA = 0.1
RUN; QUIT;
```

```
DATA RCB; SET RCB;
 IF LOCATION = "ANDALE" THEN PYIELD = (YIELD/49.85)*100;
 IF LOCATION = "KINGMAN" THEN PYIELD = (YIELD/24.80)*100;
 IF LOCATION = "KIOWA" THEN PYIELD = (YIELD/71.41)*100;
 IF LOCATION = "STAFFORD" THEN PYIELD = (YIELD/24.26)*100;
 IF LOCATION = "SUMNER" THEN PYIELD = (YIELD/24.9)*100;
RUN;

PROC SORT; BY LOCATION;
RUN;

PROC MEANS DATA=RCB NOPRINT MEAN; BY LOCATION;
 CLASS PLOT LOCATION BLOCK GENOTYPE TYPE SR;
 VAR FALL_PLANT_DENSITY_ACRE SPR_PLANT_DENSITY_ACRE WS PYIELD YIELD;
 OUTPUT OUT=PLOTMEANS MEAN=;
RUN;

DATA PLOTMEANS; SET PLOTMEANS;
 IF LOC=5 THEN LOCATION="ANDALE";
 IF LOC=1 THEN LOCATION="KINGMAN";
 IF LOC=3 THEN LOCATION="KIOWA";
 IF LOC=4 THEN LOCATION="STAFFORD";
 IF LOC=2 THEN LOCATION="SUMNER";
RUN;

PROC SORT; BY LOCATION;
RUN;

PROC PRINT DATA=PLOTMEANS;
RUN;

PROC CORR DATA=PLOTMEANS; BY LOCATION;
 VAR FALL_PLANT_DENSITY_ACRE SPR_PLANT_DENSITY_ACRE WS PYIELD YIELD;
RUN;
```

Appendix B - Raw Data: "The Effect of Residue Management, Row Spacing, and Seeding Rate on Winter Canola Establishment and Survival"

Year	Location	Plot	BLOCK	TREATMENT	Sub-sample	Fall plant stage	Fall stand acre^{-1}	Spring stand acre^{-1}	Winter survival	Bloom progression	Yield	Oil concentration
2015-16	ANDALE	101	1	AGCO-30-150000	1	3	143394	5311	4	60	36.61	39.6
2015-16	ANDALE	101	1	AGCO-30-150000	2	4	138083	26554	19			
2015-16	ANDALE	101	1	AGCO-30-150000	3	4	111529	26554	24			
2015-16	ANDALE	101	1	AGCO-30-150000	4	4	281478	21244	8			
2015-16	ANDALE	102	1	AGCO-20-150000	1	5	231024	31865	14	45	40.30	40.4
2015-16	ANDALE	102	1	AGCO-20-150000	2	5	302721	103563	34			
2015-16	ANDALE	102	1	AGCO-20-150000	3	5	183226	87630	48			
2015-16	ANDALE	102	1	AGCO-20-150000	4	5	135428	55764	41			
2015-16	ANDALE	103	1	AGCO-30-200000	1	5	260234	5311	2	50	38.03	41.6
2015-16	ANDALE	103	1	AGCO-30-200000	2	5	207125	53109	26			
2015-16	ANDALE	103	1	AGCO-30-200000	3	5	233680	47798	20			
2015-16	ANDALE	103	1	AGCO-30-200000	4	5	164638	58420	35			
2015-16	ANDALE	104	1	AGCO-20-200000	1	5	318654	71697	23	60	42.66	40.7
2015-16	ANDALE	104	1	AGCO-20-200000	2	5	350519	63731	18			
2015-16	ANDALE	104	1	AGCO-20-200000	3	5	278822	47798	17			
2015-16	ANDALE	104	1	AGCO-20-200000	4	5	278822	63731	23			
2015-16	ANDALE	105	1	AGCO-30-100000	1	5	127462	10622	8	50	43.51	41.3
2015-16	ANDALE	105	1	AGCO-30-100000	2	5	106218	10622	10			
2015-16	ANDALE	105	1	AGCO-30-100000	3	5	132772	58420	44			

2015-16	ANDALE	105	1	AGCO-30-100000	4	5	201814	37176	18			
2015-16	ANDALE	106	1	AGCO-20-100000	1	5	215091	111529	52	40	49.85	41.2
2015-16	ANDALE	106	1	AGCO-20-100000	2	5	270856	31865	12			
2015-16	ANDALE	106	1	AGCO-20-100000	3	5	167293	135428	81			
2015-16	ANDALE	106	1	AGCO-20-100000	4	5	159327	111529	70			
2015-16	ANDALE	107	1	FARMER-30-191600	1	4	116840	31865	27	50	42.00	39.3
2015-16	ANDALE	107	1	FARMER-30-191600	2	4	79663	37176	47			
2015-16	ANDALE	107	1	FARMER-30-191600	3	4	138083	15933	12			
2015-16	ANDALE	107	1	FARMER-30-191600	4	4	212436	37176	18			
2015-16	ANDALE	108	1	FARMER-30-191600	1	4	100907	31865	32	45	37.65	39.2
2015-16	ANDALE	108	1	FARMER-30-191600	2	4	84974	15933	19			
2015-16	ANDALE	108	1	FARMER-30-191600	3	4	84974	37176	44			
2015-16	ANDALE	108	1	FARMER-30-191600	4	4	127462	31865	25			
2015-16	ANDALE	109	1	FARMER-30-191600	1	4	79663	31865	40	50	33.49	38.7
2015-16	ANDALE	109	1	FARMER-30-191600	2	4	127462	47798	38			
2015-16	ANDALE	109	1	FARMER-30-191600	3	4	84974	31865	38			
2015-16	ANDALE	109	1	FARMER-30-191600	4	4	154016	37176	24			
2015-16	ANDALE	201	2	FARMER-30-191600	1	4	100907	21244	21	45	40.58	39.4
2015-16	ANDALE	201	2	FARMER-30-191600	2	4	90285	42487	47			
2015-16	ANDALE	201	2	FARMER-30-191600	3	4	122151	37176	30			
2015-16	ANDALE	201	2	FARMER-30-191600	4	4	148705	47798	32			
2015-16	ANDALE	202	2	FARMER-30-191600	1	4	69042	31865	46	50	43.42	39.6
2015-16	ANDALE	202	2	FARMER-30-191600	2	4	132772	53109	40			
2015-16	ANDALE	202	2	FARMER-30-191600	3	4	84974	58420	69			
2015-16	ANDALE	202	2	FARMER-30-191600	4	4	127462	58420	46			
2015-16	ANDALE	203	2	FARMER-30-191600	1	4	143394	21244	15	50	46.26	39.8
2015-16	ANDALE	203	2	FARMER-30-191600	2	4	132772	63731	48			
2015-16	ANDALE	203	2	FARMER-30-191600	3	4	74353	26554	36			
2015-16	ANDALE	203	2	FARMER-30-191600	4	4	106218	47798	45			
2015-16	ANDALE	204	2	AGCO-30-200000	1	4	238990	26554	11	45	46.16	39.9
2015-16	ANDALE	204	2	AGCO-30-200000	2	5	270856	47798	18			
2015-16	ANDALE	204	2	AGCO-30-200000	3	5	276167	21244	8			
2015-16	ANDALE	204	2	AGCO-30-200000	4	5	223058	10622	5			
2015-16	ANDALE	205	2	AGCO-20-200000	1	5	302721	95596	32	60	45.97	41.3

2015-16	ANDALE	205	2	AGCO-20-200000	2	5	310688	95596	31			
2015-16	ANDALE	205	2	AGCO-20-200000	3	5	286789	95596	33			
2015-16	ANDALE	205	2	AGCO-20-200000	4	5	278822	23899	9			
2015-16	ANDALE	206	2	AGCO-30-100000	1	5	132772	37176	28	55	41.24	41.1
2015-16	ANDALE	206	2	AGCO-30-100000	2	5	138083	74353	54			
2015-16	ANDALE	206	2	AGCO-30-100000	3	5	100907	53109	53			
2015-16	ANDALE	206	2	AGCO-30-100000	4	5	207125	0	0			
2015-16	ANDALE	207	2	AGCO-20-100000	1	5	254923	119495	47	10	43.61	41.1
2015-16	ANDALE	207	2	AGCO-20-100000	2	5	215091	127462	59			
2015-16	ANDALE	207	2	AGCO-20-100000	3	5	286789	79663	28			
2015-16	ANDALE	207	2	AGCO-20-100000	4	5	334587	71697	21			
2015-16	ANDALE	208	2	AGCO-30-150000	1	5	217747	21244	10	50	31.59	40.8
2015-16	ANDALE	208	2	AGCO-30-150000	2	5	191192	63731	33			
2015-16	ANDALE	208	2	AGCO-30-150000	3	5	191192	31865	17			
2015-16	ANDALE	208	2	AGCO-30-150000	4	5	223058	37176	17			
2015-16	ANDALE	209	2	AGCO-20-150000	1	5	366452	63731	17	20	31.97	40.7
2015-16	ANDALE	209	2	AGCO-20-150000	2	5	238990	119495	50			
2015-16	ANDALE	209	2	AGCO-20-150000	3	5	238990	31865	13			
2015-16	ANDALE	209	2	AGCO-20-150000	4	5	286789	47798	17			
2015-16	ANDALE	301	3	FARMER-30-191600	1	4	132772	26554	20	60	28.00	39.7
2015-16	ANDALE	301	3	FARMER-30-191600	2	4	100907	37176	37			
2015-16	ANDALE	301	3	FARMER-30-191600	3	4	127462	42487	33			
2015-16	ANDALE	301	3	FARMER-30-191600	4	4	143394	31865	22			
2015-16	ANDALE	302	3	FARMER-30-191600	1	4	79663	37176	47	60	25.02	39.1
2015-16	ANDALE	302	3	FARMER-30-191600	2	4	100907	42487	42			
2015-16	ANDALE	302	3	FARMER-30-191600	3	4	111529	15933	14			
2015-16	ANDALE	302	3	FARMER-30-191600	4	4	116840	37176	32			
2015-16	ANDALE	303	3	FARMER-30-191600	1	4	100907	31865	32	45	32.16	40.3
2015-16	ANDALE	303	3	FARMER-30-191600	2	4	169949	95596	56			
2015-16	ANDALE	303	3	FARMER-30-191600	3	4	116840	47798	41			
2015-16	ANDALE	303	3	FARMER-30-191600	4	4	127462	21244	17			
2015-16	ANDALE	304	3	AGCO-20-100000	1	4	199159	111529	56	55	26.49	41.2
2015-16	ANDALE	304	3	AGCO-20-100000	2	4	199159	95596	48			
2015-16	ANDALE	304	3	AGCO-20-100000	3	4	159327	103563	65			

2015-16	ANDALE	304	3	AGCO-20-100000	4	4	151361	55764	37			
2015-16	ANDALE	305	3	AGCO-30-100000	1	5	164638	42487	26	50	24.59	39.1
2015-16	ANDALE	305	3	AGCO-30-100000	2	4	233680	15933	7			
2015-16	ANDALE	305	3	AGCO-30-100000	3	5	116840	0	0			
2015-16	ANDALE	305	3	AGCO-30-100000	4	5	191192	10622	6			
2015-16	ANDALE	306	3	AGCO-20-150000	1	5	326620	79663	24	40	30.98	38.5
2015-16	ANDALE	306	3	AGCO-20-150000	2	5	199159	87630	44			
2015-16	ANDALE	306	3	AGCO-20-150000	3	5	191192	127462	67			
2015-16	ANDALE	306	3	AGCO-20-150000	4	5	238990	111529	47			
2015-16	ANDALE	307	3	AGCO-30-150000	1	4	180571	10622	6	20	20.72	38.9
2015-16	ANDALE	307	3	AGCO-30-150000	2	4	233680	42487	18			
2015-16	ANDALE	307	3	AGCO-30-150000	3	4	265545	5311	2			
2015-16	ANDALE	307	3	AGCO-30-150000	4	4	244301	63731	26			
2015-16	ANDALE	308	3	AGCO-20-200000	1	5	342553	7966	2	10	22.61	39.4
2015-16	ANDALE	308	3	AGCO-20-200000	2	5	366452	143394	39			
2015-16	ANDALE	308	3	AGCO-20-200000	3	5	262890	0	0			
2015-16	ANDALE	308	3	AGCO-20-200000	4	5	342553	0	0			
2015-16	ANDALE	309	3	AGCO-30-200000	1	5	292099	26554	9	5	19.58	40.1
2015-16	ANDALE	309	3	AGCO-30-200000	2	5	233680	42487	18			
2015-16	ANDALE	309	3	AGCO-30-200000	3	5	201814	63731	32			
2015-16	ANDALE	309	3	AGCO-30-200000	4	5	233680	5311	2			
2015-16	KINGMAN	101	1	FARMER-10-684000	1	4	224770	203861	91	45	17.44	43.45
2015-16	KINGMAN	101	1	FARMER-10-684000	2	4	209088	203861	98			
2015-16	KINGMAN	101	1	FARMER-10-684000	3	4	214315	203861	95			
2015-16	KINGMAN	101	1	FARMER-10-684000	4	4	277042	250906	91			
2015-16	KINGMAN	102	1	FARMER-10-684000	1	4	250906	141134	56	40	13.53	42.26
2015-16	KINGMAN	102	1	FARMER-10-684000	2	4	209088	198634	95			
2015-16	KINGMAN	102	1	FARMER-10-684000	3	4	224770	193406	86			
2015-16	KINGMAN	102	1	FARMER-10-684000	4	4	271814	261360	96			
2015-16	KINGMAN	103	1	FARMER-10-684000	1	4	235224	219542	93	40	10.72	42.8
2015-16	KINGMAN	103	1	FARMER-10-684000	2	4	229997	214315	93			
2015-16	KINGMAN	103	1	FARMER-10-684000	3	4	240451	209088	87			
2015-16	KINGMAN	103	1	FARMER-10-684000	4	4	245678	229997	94			
2015-16	KINGMAN	104	1	AGCO-20-150000	1	4	104544	101930	98	45	22.04	42.63

2015-16	KINGMAN	104	1	AGCO-20-150000	2	4	117612	109771	93			
2015-16	KINGMAN	104	1	AGCO-20-150000	3	4	122839	114998	94			
2015-16	KINGMAN	104	1	AGCO-20-150000	4	4	169884	164657	97			
2015-16	KINGMAN	105	1	AGCO-30-100000	1	4	59242	57499	97	55	23.80	42.63
2015-16	KINGMAN	105	1	AGCO-30-100000	2	4	76666	73181	95			
2015-16	KINGMAN	105	1	AGCO-30-100000	3	4	73181	67954	93			
2015-16	KINGMAN	105	1	AGCO-30-100000	4	4	74923	66211	88			
2015-16	KINGMAN	106	1	AGCO-20-200000	1	4	135907	107158	79	50	20.88	43.3
2015-16	KINGMAN	106	1	AGCO-20-200000	2	4	112385	104544	93			
2015-16	KINGMAN	106	1	AGCO-20-200000	3	4	120226	117612	98			
2015-16	KINGMAN	106	1	AGCO-20-200000	4	4	104544	101930	98			
2015-16	KINGMAN	107	1	AGCO-30-150000	1	4	71438	64469	90	55	22.96	43.33
2015-16	KINGMAN	107	1	AGCO-30-150000	2	4	50530	48787	97			
2015-16	KINGMAN	107	1	AGCO-30-150000	3	4	85378	76666	90			
2015-16	KINGMAN	107	1	AGCO-30-150000	4	4	87120	85378	98			
2015-16	KINGMAN	108	1	AGCO-20-100000	1	5	94090	75794	81	50	24.82	42.65
2015-16	KINGMAN	108	1	AGCO-20-100000	2	5	107158	91476	85			
2015-16	KINGMAN	108	1	AGCO-20-100000	3	5	101930	91476	90			
2015-16	KINGMAN	108	1	AGCO-20-100000	4	5	83635	81022	97			
2015-16	KINGMAN	109	1	AGCO-30-200000	1	5	158558	102802	65	55	19.95	42.47
2015-16	KINGMAN	109	1	AGCO-30-200000	2	5	62726	59242	94			
2015-16	KINGMAN	109	1	AGCO-30-200000	3	5	116741	111514	96			
2015-16	KINGMAN	109	1	AGCO-30-200000	4	5	83635	78408	94			
2015-16	KINGMAN	201	2	FARMER-10-684000	1	4	271814	224770	83	40	14.84	42.09
2015-16	KINGMAN	201	2	FARMER-10-684000	2	4	282269	256133	91			
2015-16	KINGMAN	201	2	FARMER-10-684000	3	4	256133	240451	94			
2015-16	KINGMAN	201	2	FARMER-10-684000	4	4	214315	188179	88			
2015-16	KINGMAN	202	2	FARMER-10-684000	1	4	193406	188179	97	35	16.70	43.53
2015-16	KINGMAN	202	2	FARMER-10-684000	2	4	339768	313632	92			
2015-16	KINGMAN	202	2	FARMER-10-684000	3	4	277042	224770	81			
2015-16	KINGMAN	202	2	FARMER-10-684000	4	4	214315	188179	88			
2015-16	KINGMAN	203	2	FARMER-10-684000	1	4	287496	229997	80	45	17.16	43.06
2015-16	KINGMAN	203	2	FARMER-10-684000	2	4	224770	219542	98			
2015-16	KINGMAN	203	2	FARMER-10-684000	3	4	292723	261360	89			

2015-16	KINGMAN	203	2	FARMER-10-684000	4	4	303178	282269	93			
2015-16	KINGMAN	204	2	AGCO-20-150000	1	3	112385	104544	93	60	22.96	41.09
2015-16	KINGMAN	204	2	AGCO-20-150000	2	3	86249	83635	97			
2015-16	KINGMAN	204	2	AGCO-20-150000	3	3	162043	156816	97			
2015-16	KINGMAN	204	2	AGCO-20-150000	4	3	122839	104544	85			
2015-16	KINGMAN	205	2	AGCO-30-200000	1	4	135907	109771	81	55	19.95	42.54
2015-16	KINGMAN	205	2	AGCO-30-200000	2	4	94090	90605	96			
2015-16	KINGMAN	205	2	AGCO-30-200000	3	4	99317	83635	84			
2015-16	KINGMAN	205	2	AGCO-30-200000	4	4	101059	95832	95			
2015-16	KINGMAN	206	2	AGCO-20-200000	1	4	148975	114998	77	55	20.88	44.14
2015-16	KINGMAN	206	2	AGCO-20-200000	2	4	120226	114998	96			
2015-16	KINGMAN	206	2	AGCO-20-200000	3	4	141134	128066	91			
2015-16	KINGMAN	206	2	AGCO-20-200000	4	4	156816	151589	97			
2015-16	KINGMAN	207	2	AGCO-30-150000	1	4	99317	55757	56	50	21.80	42.25
2015-16	KINGMAN	207	2	AGCO-30-150000	2	4	76666	69696	91			
2015-16	KINGMAN	207	2	AGCO-30-150000	3	4	94090	62726	67			
2015-16	KINGMAN	207	2	AGCO-30-150000	4	4	101059	81893	81			
2015-16	KINGMAN	208	2	AGCO-20-100000	1	4	169884	65340	38	55	23.43	42.91
2015-16	KINGMAN	208	2	AGCO-20-100000	2	4	154202	88862	58			
2015-16	KINGMAN	208	2	AGCO-20-100000	3	4	162043	75794	47			
2015-16	KINGMAN	208	2	AGCO-20-100000	4	4	86249	67954	79			
2015-16	KINGMAN	209	2	AGCO-30-100000	1	4	71438	48787	68	55	22.96	43.38
2015-16	KINGMAN	209	2	AGCO-30-100000	2	4	64469	57499	89			
2015-16	KINGMAN	209	2	AGCO-30-100000	3	4	62726	38333	61			
2015-16	KINGMAN	209	2	AGCO-30-100000	4	4	80150	73181	91			
2015-16	KINGMAN	301	3	AGCO-20-150000	1	4	109771	83635	76	60	20.64	42.49
2015-16	KINGMAN	301	3	AGCO-20-150000	2	4	104544	81022	78			
2015-16	KINGMAN	301	3	AGCO-20-150000	3	4	99317	54886	55			
2015-16	KINGMAN	301	3	AGCO-20-150000	4	4	162043	128066	79			
2015-16	KINGMAN	302	3	AGCO-30-200000	1	4	114998	97574	85	50	19.95	42.18
2015-16	KINGMAN	302	3	AGCO-30-200000	2	4	128938	109771	85			
2015-16	KINGMAN	302	3	AGCO-30-200000	3	4	76666	74923	98			
2015-16	KINGMAN	302	3	AGCO-30-200000	4	4	88862	87120	98			
2015-16	KINGMAN	303	3	AGCO-20-200000	1	4	146362	112385	77	45	18.79	42.14

2015-16	KINGMAN	303	3	AGCO-20-200000	2	4	156816	122839	78			
2015-16	KINGMAN	303	3	AGCO-20-200000	3	4	146362	114998	79			
2015-16	KINGMAN	303	3	AGCO-20-200000	4	4	109771	107158	98			
2015-16	KINGMAN	304	3	AGCO-30-150000	1	5	97574	76666	79	40	21.57	43.65
2015-16	KINGMAN	304	3	AGCO-30-150000	2	5	108029	74923	69			
2015-16	KINGMAN	304	3	AGCO-30-150000	3	5	95832	57499	60			
2015-16	KINGMAN	304	3	AGCO-30-150000	4	5	73181	71438	98			
2015-16	KINGMAN	305	3	AGCO-20-100000	1	5	141134	70567	50	55	24.35	42.68
2015-16	KINGMAN	305	3	AGCO-20-100000	2	5	114998	73181	64			
2015-16	KINGMAN	305	3	AGCO-20-100000	3	5	130680	99317	76			
2015-16	KINGMAN	305	3	AGCO-20-100000	4	5	120226	83635	70			
2015-16	KINGMAN	306	3	AGCO-30-100000	1	4	48787	47045	96	50	22.50	43.59
2015-16	KINGMAN	306	3	AGCO-30-100000	2	4	48787	48787	100			
2015-16	KINGMAN	306	3	AGCO-30-100000	3	4	99317	74923	75			
2015-16	KINGMAN	306	3	AGCO-30-100000	4	4	87120	55757	64			
2015-16	KINGMAN	307	3	FARMER-10-684000	1	4	182952	162043	89	30	16.11	41.96
2015-16	KINGMAN	307	3	FARMER-10-684000	2	4	240451	188179	78			
2015-16	KINGMAN	307	3	FARMER-10-684000	3	4	224770	193406	86			
2015-16	KINGMAN	307	3	FARMER-10-684000	4	4	198634	172498	87			
2015-16	KINGMAN	308	3	FARMER-10-684000	1	4	277042	240451	87	45	15.68	43.23
2015-16	KINGMAN	308	3	FARMER-10-684000	2	4	182952	167270	91			
2015-16	KINGMAN	308	3	FARMER-10-684000	3	4	198634	167270	84			
2015-16	KINGMAN	308	3	FARMER-10-684000	4	4	235224	198634	84			
2015-16	KINGMAN	309	3	FARMER-10-684000	1	4	156816	141134	90	45	18.83	43.19
2015-16	KINGMAN	309	3	FARMER-10-684000	2	4	182952	146362	80			
2015-16	KINGMAN	309	3	FARMER-10-684000	3	4	198634	151589	76			
2015-16	KINGMAN	309	3	FARMER-10-684000	4	4	235224	172498	73			
2015-16	KIOWA	101	1	AGCO-20-150000	1	3	65340	65340	100	100	55.54	39.09
2015-16	KIOWA	101	1	AGCO-20-150000	2	3	96703	67954	70			
2015-16	KIOWA	101	1	AGCO-20-150000	3	3	101930	73181	72			
2015-16	KIOWA	101	1	AGCO-20-150000	4	3	73181	62726	86			
2015-16	KIOWA	102	1	AGCO-30-150000	1	3	114998	74923	65	90	63.48	42.05
2015-16	KIOWA	102	1	AGCO-30-150000	2	3	125453	73181	58			
2015-16	KIOWA	102	1	AGCO-30-150000	3	3	120226	69696	58			

2015-16	KIOWA	102	1	AGCO-30-150000	4	3	118483	57499	49			
2015-16	KIOWA	103	1	AGCO-20-100000	1	3	81022	81022	100	85	63.48	42.43
2015-16	KIOWA	103	1	AGCO-20-100000	2	3	57499	57499	100			
2015-16	KIOWA	103	1	AGCO-20-100000	3	3	52272	52272	100			
2015-16	KIOWA	103	1	AGCO-20-100000	4	3	70567	67954	96			
2015-16	KIOWA	104	1	AGCO-30-200000	1	2	135907	52272	38	100	60.83	40.96
2015-16	KIOWA	104	1	AGCO-30-200000	2	2	144619	71438	49			
2015-16	KIOWA	104	1	AGCO-30-200000	3	2	125453	67954	54			
2015-16	KIOWA	104	1	AGCO-30-200000	4	2	121968	69696	57			
2015-16	KIOWA	105	1	AGCO-20-200000	1	3	65340	26136	40	85	55.54	39.44
2015-16	KIOWA	105	1	AGCO-20-200000	2	3	101930	23522	23			
2015-16	KIOWA	105	1	AGCO-20-200000	3	3	47045	41818	89			
2015-16	KIOWA	105	1	AGCO-20-200000	4	3	67954	57499	85			
2015-16	KIOWA	106	1	AGCO-30-100000	1	3	78408	48787	62	85	60.83	42.13
2015-16	KIOWA	106	1	AGCO-30-100000	2	3	19166	19166	100			
2015-16	KIOWA	106	1	AGCO-30-100000	3	3	52272	34848	67			
2015-16	KIOWA	106	1	AGCO-30-100000	4	3	62726	57499	92			
2015-16	KIOWA	107	1	FARMER-12-380000	1	3	104544	91476	88	95	60.83	38.91
2015-16	KIOWA	107	1	FARMER-12-380000	2	3	130680	130680	100			
2015-16	KIOWA	107	1	FARMER-12-380000	3	3	296208	126324	43			
2015-16	KIOWA	107	1	FARMER-12-380000	4	3	248292	139392	56			
2015-16	KIOWA	108	1	FARMER-12-380000	1							
2015-16	KIOWA	108	1	FARMER-12-380000	2							
2015-16	KIOWA	108	1	FARMER-12-380000	3							
2015-16	KIOWA	108	1	FARMER-12-380000	4							
2015-16	KIOWA	109	1	FARMER-12-380000	1							
2015-16	KIOWA	109	1	FARMER-12-380000	2							
2015-16	KIOWA	109	1	FARMER-12-380000	3							
2015-16	KIOWA	109	1	FARMER-12-380000	4							
2015-16	KIOWA	201	2	AGCO-20-150000	1	3	83635	62726	75	85	68.77	40.99
2015-16	KIOWA	201	2	AGCO-20-150000	2	3	78408	67954	87			
2015-16	KIOWA	201	2	AGCO-20-150000	3	3	112385	78408	70			
2015-16	KIOWA	201	2	AGCO-20-150000	4	3	91476	75794	83			
2015-16	KIOWA	202	2	AGCO-30-100000	1	3	69696	50530	73	80	63.48	39.16

2015-16	KIOWA	202	2	AGCO-30-100000	2	3	81893	45302	55			
2015-16	KIOWA	202	2	AGCO-30-100000	3	3	104544	52272	50			
2015-16	KIOWA	202	2	AGCO-30-100000	4	3	57499	47045	82			
2015-16	KIOWA	203	2	AGCO-20-100000	1	2	62726	57499	92	85	60.83	36.49
2015-16	KIOWA	203	2	AGCO-20-100000	2	2	47045	33977	72			
2015-16	KIOWA	203	2	AGCO-20-100000	3	2	91476	75794	83			
2015-16	KIOWA	203	2	AGCO-20-100000	4	2	99317	67954	68			
2015-16	KIOWA	204	2	AGCO-30-200000	1	2	102802	62726	61	95	60.83	41.05
2015-16	KIOWA	204	2	AGCO-30-200000	2	2	88862	66211	75			
2015-16	KIOWA	204	2	AGCO-30-200000	3	2	104544	64469	62			
2015-16	KIOWA	204	2	AGCO-30-200000	4	2	116741	74923	64			
2015-17	KIOWA	205	2	AGCO-20-200000	1	2	99317	91476	92	100	66.12	39.83
2015-18	KIOWA	205	2	AGCO-20-200000	2	2	94090	57499	61			
2015-19	KIOWA	205	2	AGCO-20-200000	3	2	88862	88862	100			
2015-20	KIOWA	205	2	AGCO-20-200000	4	2	125453	75794	60			
2015-16	KIOWA	206	2	AGCO-30-150000	1	3	78408	48787	62	90	63.48	41.84
2015-16	KIOWA	206	2	AGCO-30-150000	2	3	47045	34848	74			
2015-16	KIOWA	206	2	AGCO-30-150000	3	3	95832	62726	65			
2015-16	KIOWA	206	2	AGCO-30-150000	4	3	108029	43560	40			
2015-16	KIOWA	207	2	FARMER-12-380000	1	3	143748	108900	76	90	55.54	39.76
2015-16	KIOWA	207	2	FARMER-12-380000	2	3	174240	130680	75			
2015-16	KIOWA	207	2	FARMER-12-380000	3	3	182952	113256	62			
2015-16	KIOWA	207	2	FARMER-12-380000	4	3	257004	165528	64			
2015-16	KIOWA	208	2	FARMER-12-380000	1	3	217800	165528	76	90	66.12	45.08
2015-16	KIOWA	208	2	FARMER-12-380000	2	3	174240	126324	73			
2015-16	KIOWA	208	2	FARMER-12-380000	3	3	174240	121968	70			
2015-16	KIOWA	208	2	FARMER-12-380000	4	3	182952	174240	95			
2015-16	KIOWA	209	2	FARMER-12-380000	1	3	217800	139392	64	90	71.41	42.92
2015-16	KIOWA	209	2	FARMER-12-380000	2	3	191664	126324	66			
2015-16	KIOWA	209	2	FARMER-12-380000	3	3	261360	174240	67			
2015-16	KIOWA	209	2	FARMER-12-380000	4	3	222156	148104	67			
2015-16	KIOWA	301	3	FARMER-12-380000	1	3	121968	82764	68	90	66.12	41.08
2015-16	KIOWA	301	3	FARMER-12-380000	2	3	217800	161172	74			
2015-16	KIOWA	301	3	FARMER-12-380000	3	3	196020	182952	93			

2015-16	KIOWA	301	3	FARMER-12-380000	4	3	209088	196020	94			
2015-16	KIOWA	302	3	FARMER-12-380000	1	2	165528	135036	82	90	71.41	43.19
2015-16	KIOWA	302	3	FARMER-12-380000	2	2	178596	152460	85			
2015-16	KIOWA	302	3	FARMER-12-380000	3	2	156816	117612	75			
2015-16	KIOWA	302	3	FARMER-12-380000	4	2	200376	165528	83			
2015-16	KIOWA	303	3	FARMER-12-380000	1	3	178596	165528	93	90	71.41	44.31
2015-16	KIOWA	303	3	FARMER-12-380000	2	3	187308	126324	67			
2015-16	KIOWA	303	3	FARMER-12-380000	3	3	165528	148104	89			
2015-16	KIOWA	303	3	FARMER-12-380000	4	3	165528	139392	84			
2015-16	KIOWA	304	3	AGCO-20-100000	1	3	70567	70567	100	100	66.12	45.79
2015-16	KIOWA	304	3	AGCO-20-100000	2	3	67954	67954	100			
2015-16	KIOWA	304	3	AGCO-20-100000	3	3	99317	94090	95			
2015-16	KIOWA	304	3	AGCO-20-100000	4	3	70567	70567	100			
2015-16	KIOWA	305	3	AGCO-30-150000	1	3	106286	55757	52	95	60.83	42.32
2015-16	KIOWA	305	3	AGCO-30-150000	2	3	81893	31363	38			
2015-16	KIOWA	305	3	AGCO-30-150000	3	3	52272	41818	80			
2015-16	KIOWA	305	3	AGCO-30-150000	4	3	97574	45302	46			
2015-16	KIOWA	306	3	AGCO-20-200000	1	2	101930	75794	74	100	63.48	43.73
2015-16	KIOWA	306	3	AGCO-20-200000	2	2	107158	75794	71			
2015-16	KIOWA	306	3	AGCO-20-200000	3	2	128066	75794	59			
2015-16	KIOWA	306	3	AGCO-20-200000	4	2	99317	78408	79			
2015-16	KIOWA	307	3	AGCO-30-100000	1	3	64469	41818	65	90	66.12	41
2015-16	KIOWA	307	3	AGCO-30-100000	2	3	81893	50530	62			
2015-16	KIOWA	307	3	AGCO-30-100000	3	3	80150	60984	76			
2015-16	KIOWA	307	3	AGCO-30-100000	4	3	60984	55757	91			
2015-16	KIOWA	308	3	AGCO-20-150000	1	2	86249	65340	76	100	63.48	40.01
2015-16	KIOWA	308	3	AGCO-20-150000	2	2	120226	67954	57			
2015-16	KIOWA	308	3	AGCO-20-150000	3	2	94090	83635	89			
2015-16	KIOWA	308	3	AGCO-20-150000	4	2	88862	88862	100			
2015-16	KIOWA	309	3	AGCO-30-200000	1	3	87120	54014	62	100	63.48	42.43
2015-16	KIOWA	309	3	AGCO-30-200000	2	3	114998	67954	59			
2015-16	KIOWA	309	3	AGCO-30-200000	3	3	116741	64469	55			
2015-16	KIOWA	309	3	AGCO-30-200000	4	3	118483	55757	47			
2015-16	STAFFORD	101	1	FARMER-30-312500	1	4	97574	50530	52	70	7.24	40.86

2015-16	STAFFORD	101	1	FARMER-30-312500	2	4	127195	36590	29			
2015-16	STAFFORD	101	1	FARMER-30-312500	3	4	80150	40075	50			
2015-16	STAFFORD	101	1	FARMER-30-312500	4	4	80150	52272	65			
2015-16	STAFFORD	102	1	FARMER-30-312500	1	3	80150	38333	48	60	10.03	40.46
2015-16	STAFFORD	102	1	FARMER-30-312500	2	3	231739	97574	42			
2015-16	STAFFORD	102	1	FARMER-30-312500	3	3	120226	34848	29			
2015-16	STAFFORD	102	1	FARMER-30-312500	4	3	165528	60984	37			
2015-16	STAFFORD	103	1	FARMER-30-312500	1	4	148104	66211	45	65	15.72	39.54
2015-16	STAFFORD	103	1	FARMER-30-312500	2	4	196891	104544	53			
2015-16	STAFFORD	103	1	FARMER-30-312500	3	4	113256	95832	85			
2015-16	STAFFORD	103	1	FARMER-30-312500	4	4	128938	81893	64			
2015-16	STAFFORD	104	1	AGCO-20-200000	1	5	190793	112385	59	65	14.61	42.23
2015-16	STAFFORD	104	1	AGCO-20-200000	2	5	146362	104544	71			
2015-16	STAFFORD	104	1	AGCO-20-200000	3	5	201247	135907	68			
2015-16	STAFFORD	104	1	AGCO-20-200000	4	5	180338	154202	86			
2015-16	STAFFORD	105	1	AGCO-30-150000	1	4	31363	29621	94	70	17.76	40.86
2015-16	STAFFORD	105	1	AGCO-30-150000	2	4	43560	41818	96			
2015-16	STAFFORD	105	1	AGCO-30-150000	3	4	50530	38333	76			
2015-16	STAFFORD	105	1	AGCO-30-150000	4	4	54014	38333	71			
2015-16	STAFFORD	106	1	AGCO-20-100000	1	3	96703	57499	59	75	16.16	38.74
2015-16	STAFFORD	106	1	AGCO-20-100000	2	3	86249	60113	70			
2015-16	STAFFORD	106	1	AGCO-20-100000	3	3	78408	65340	83			
2015-16	STAFFORD	106	1	AGCO-20-100000	4	3	101930	57499	56			
2015-16	STAFFORD	107	1	AGCO-30-100000	1	4	118483	59242	50	70	23.15	42.46
2015-16	STAFFORD	107	1	AGCO-30-100000	2	4	83635	54014	65			
2015-16	STAFFORD	107	1	AGCO-30-100000	3	4	90605	50530	56			
2015-16	STAFFORD	107	1	AGCO-30-100000	4	4	106286	60984	57			
2015-16	STAFFORD	108	1	AGCO-20-200000	1	5	164657	83635	51	75	16.16	41.51
2015-16	STAFFORD	108	1	AGCO-20-200000	2	5	240451	86249	36			
2015-16	STAFFORD	108	1	AGCO-20-200000	3	5	190793	86249	45			
2015-16	STAFFORD	108	1	AGCO-20-200000	4	5	279655	67954	24			
2015-16	STAFFORD	109	2	AGCO-30-200000	1	3	59242	24394	41	70	14.30	41.94
2015-16	STAFFORD	109	2	AGCO-30-200000	2	3	83635	31363	38			
2015-16	STAFFORD	109	2	AGCO-30-200000	3	3	106286	33106	31			

2015-16	STAFFORD	109	2	AGCO-30-200000	4	3	106286	45302	43				
2015-16	STAFFORD	201	2	AGCO-20-100000	1	4	114998	104544	91		80	13.62	42.5
2015-16	STAFFORD	201	2	AGCO-20-100000	2	4	148975	125453	84				
2015-16	STAFFORD	201	2	AGCO-20-100000	3	4	154202	109771	71				
2015-16	STAFFORD	201	2	AGCO-20-100000	4	4	154202	125453	81				
2015-16	STAFFORD	203	2	AGCO-30-200000	1	3	59242	47045	79		75	24.94	40.21
2015-16	STAFFORD	203	2	AGCO-30-200000	2	3	83635	67954	81				
2015-16	STAFFORD	203	2	AGCO-30-200000	3	3	106286	66211	62				
2015-16	STAFFORD	203	2	AGCO-30-200000	4	3	106286	67954	64				
2015-16	STAFFORD	204	2	AGCO-20-100000	1	4	104544	73181	70		70	14.98	41.87
2015-16	STAFFORD	204	2	AGCO-20-100000	2	4	219542	75794	35				
2015-16	STAFFORD	204	2	AGCO-20-100000	3	4	151589	81022	53				
2015-16	STAFFORD	204	2	AGCO-20-100000	4	4	112385	112385	100				
2015-16	STAFFORD	205	2	AGCO-30-150000	1	4	62726	50530	81		80	7.55	40.52
2015-16	STAFFORD	205	2	AGCO-30-150000	2	4	88862	62726	71				
2015-16	STAFFORD	205	2	AGCO-30-150000	3	4	71438	57499	80				
2015-16	STAFFORD	205	2	AGCO-30-150000	4	4	102802	41818	41				
2015-16	STAFFORD	206	2	AGCO-20-150000	1	4	104544	70567	68		65	10.89	42.2
2015-16	STAFFORD	206	2	AGCO-20-150000	2	4	219542	70567	32				
2015-16	STAFFORD	206	2	AGCO-20-150000	3	4	151589	78408	52				
2015-16	STAFFORD	206	2	AGCO-20-150000	4	4	112385	78408	70				
2015-16	STAFFORD	207	2	FARMER-30-312500	1	4	109771	76666	70		60	12.19	41.89
2015-16	STAFFORD	207	2	FARMER-30-312500	2	4	104544	73181	70				
2015-16	STAFFORD	207	2	FARMER-30-312500	3	4	99317	83635	84				
2015-16	STAFFORD	207	2	FARMER-30-312500	4	4	95832	80150	84				
2015-16	STAFFORD	208	2	FARMER-30-312500	1	4	128938	62726	49		65	5.51	43
2015-16	STAFFORD	208	2	FARMER-30-312500	2	4	109771	71438	65				
2015-16	STAFFORD	208	2	FARMER-30-312500	3	4	118483	94090	79				
2015-16	STAFFORD	208	2	FARMER-30-312500	4	4	181210	60984	34				
2015-16	STAFFORD	209	2	FARMER-30-312500	1	5	113256	66211	58		75	9.47	39.52
2015-16	STAFFORD	209	2	FARMER-30-312500	2	5	141134	45302	32				
2015-16	STAFFORD	209	2	FARMER-30-312500	3	5	167270	47045	28				
2015-16	STAFFORD	209	2	FARMER-30-312500	4	5	141134	64469	46				
2015-16	STAFFORD	301	3	AGCO-20-100000	1	3	65340	49658	76				42.78

2015-16	STAFFORD	301	3	AGCO-20-100000	2	3	70567	57499	81			
2015-16	STAFFORD	301	3	AGCO-20-100000	3	3	52272	52272	100			
2015-16	STAFFORD	301	3	AGCO-20-100000	4	3	78408	65340	83			
2015-16	STAFFORD	302	3	AGCO-30-100000	1	3	87120	41818	48	70	16.96	40.09
2015-16	STAFFORD	302	3	AGCO-30-100000	2	3	108029	64469	60			
2015-16	STAFFORD	302	3	AGCO-30-100000	3	3	128938	66211	51			
2015-16	STAFFORD	302	3	AGCO-30-100000	4	3	137650	74923	54			
2015-16	STAFFORD	303	3	AGCO-20-150000	1	5	143748	88862	62	75	21.66	38.98
2015-16	STAFFORD	303	3	AGCO-20-150000	2	5	83635	78408	94			
2015-16	STAFFORD	303	3	AGCO-20-150000	3	5	156816	122839	78			
2015-16	STAFFORD	303	3	AGCO-20-150000	4	5	143748	112385	78			
2015-16	STAFFORD	304	3	AGCO-30-150000	1	3	114998	55757	48	65	23.58	
2015-16	STAFFORD	304	3	AGCO-30-150000	2	3	87120	45302	52			
2015-16	STAFFORD	304	3	AGCO-30-150000	3	3	109771	62726	57			
2015-16	STAFFORD	304	3	AGCO-30-150000	4	3	163786	57499	35			
2015-16	STAFFORD	305	3	AGCO-20-200000	1	4	81022	78408	97	60	23.03	44.8
2015-16	STAFFORD	305	3	AGCO-20-200000	2	4	104544	36590	35			
2015-16	STAFFORD	305	3	AGCO-20-200000	3	4	135907	83635	62			
2015-16	STAFFORD	305	3	AGCO-20-200000	4	4	112385	107158	95			
2015-16	STAFFORD	306	3	AGCO-30-200000	1	5	90605	57499	63	60	24.26	39.98
2015-16	STAFFORD	306	3	AGCO-30-200000	2	5	121968	87120	71			
2015-16	STAFFORD	306	3	AGCO-30-200000	3	5	113256	90605	80			
2015-16	STAFFORD	306	3	AGCO-30-200000	4	5	87120	69696	80			
2015-16	STAFFORD	307	3	FARMER-30-312500	1	5	78408	48787	62	60	15.35	41.08
2015-16	STAFFORD	307	3	FARMER-30-312500	2	4	142877	99317	70			
2015-16	STAFFORD	307	3	FARMER-30-312500	3	4	158558	78408	49			
2015-16	STAFFORD	307	3	FARMER-30-312500	4	4	155074	74923	48			
2015-16	STAFFORD	308	3	FARMER-30-312500	1	4	162043	90605	56	65	17.83	41.86
2015-16	STAFFORD	308	3	FARMER-30-312500	2	4	125453	76666	61			
2015-16	STAFFORD	308	3	FARMER-30-312500	3	4	221285	78408	35			
2015-16	STAFFORD	308	3	FARMER-30-312500	4	4	165528	92347	56			
2015-16	STAFFORD	309	3	FARMER-30-312500	1	3	149846	83635	56	65	18.75	40.68
2015-16	STAFFORD	309	3	FARMER-30-312500	2	3	134165	74923	56			
2015-16	STAFFORD	309	3	FARMER-30-312500	3	3	135907	69696	51			

2015-16	STAFFORD	309	3	FARMER-30-312500	4	3	163786	76666	47			
2015-16	SUMNER	101	1	AGCO-20-100000	1	3	67954	41818	62	40	23.54	41.69
2015-16	SUMNER	101	1	AGCO-20-100000	2	3	52272	47045	90			
2015-16	SUMNER	101	1	AGCO-20-100000	3	3	47045	41818	89			
2015-16	SUMNER	101	1	AGCO-20-100000	4	3	36590	36590	100			
2015-16	SUMNER	102	1	AGCO-30-100000	1	3	52272	29621	57	30	22.37	40.56
2015-16	SUMNER	102	1	AGCO-30-100000	2	3	59242	29621	50			
2015-16	SUMNER	102	1	AGCO-30-100000	3	3	43560	34848	80			
2015-16	SUMNER	102	1	AGCO-30-100000	4	3	69696	54014	78			
2015-16	SUMNER	103	1	AGCO-20-200000	1	4	65340	44431	68	35	24.15	41.32
2015-16	SUMNER	103	1	AGCO-20-200000	2	4	114998	78408	68			
2015-16	SUMNER	103	1	AGCO-20-200000	3	4	65340	57499	88			
2015-16	SUMNER	103	1	AGCO-20-200000	4	4	91476	70567	77			
2015-16	SUMNER	104	1	AGCO-30-200000	1	3	71438	45302	63	25	22.32	40.85
2015-16	SUMNER	104	1	AGCO-30-200000	2	3	59242	33106	56			
2015-16	SUMNER	104	1	AGCO-30-200000	3	3	104544	40075	38			
2015-16	SUMNER	104	1	AGCO-30-200000	4	3	121968	71438	59			
2015-16	SUMNER	105	1	AGCO-20-150000	1	3	39204	33977	87	30	23.64	39.31
2015-16	SUMNER	105	1	AGCO-20-150000	2	3	65340	49658	76			
2015-16	SUMNER	105	1	AGCO-20-150000	3	3	47045	36590	78			
2015-16	SUMNER	105	1	AGCO-20-150000	4	3	52272	33977	65			
2015-16	SUMNER	106	1	AGCO-30-150000	1	4	52272	47045	90	40	22.46	39.7
2015-16	SUMNER	106	1	AGCO-30-150000	2	4	76666	59242	77			
2015-16	SUMNER	106	1	AGCO-30-150000	3	4	33106	24394	74			
2015-16	SUMNER	106	1	AGCO-30-150000	4	4	22651	20909	92			
2015-16	SUMNER	107	1	FARMER-15-562500	1	4	184694	132422	72	15	23.21	41.54
2015-16	SUMNER	107	1	FARMER-15-562500	2	4	202118	111514	55			
2015-16	SUMNER	107	1	FARMER-15-562500	3	4	195149	142877	73			
2015-16	SUMNER	107	1	FARMER-15-562500	4	4	226512	167270	74			
2015-16	SUMNER	108	1	FARMER-15-562500	1	4	181210	177725	98	15	21.90	42.77
2015-16	SUMNER	108	1	FARMER-15-562500	2	4	247421	174240	70			
2015-16	SUMNER	108	1	FARMER-15-562500	3	4	177725	163786	92			
2015-16	SUMNER	108	1	FARMER-15-562500	4	4	146362	139392	95			
2015-16	SUMNER	109	1	FARMER-15-562500	1	3	174240	142877	82	10	22.65	42.18

2015-16	SUMNER	109	1	FARMER-15-562500	2	3	195149	135907	70				
2015-16	SUMNER	109	1	FARMER-15-562500	3	3	177725	146362	82				
2015-16	SUMNER	109	1	FARMER-15-562500	4	3	261360	209088	80				
2015-16	SUMNER	201	2	AGCO-20-200000	1	3	88862	78408	88	20	20.39	40.31
2015-16	SUMNER	201	2	AGCO-20-200000	2	3	81022	44431	55			
2015-16	SUMNER	201	2	AGCO-20-200000	3	3	88862	49658	56			
2015-16	SUMNER	201	2	AGCO-20-200000	4	3	91476	65340	71			
2015-16	SUMNER	202	2	AGCO-30-100000	1	3	33106	27878	84	50	24.90	42.95
2015-16	SUMNER	202	2	AGCO-30-100000	2	3	66211	57499	87			
2015-16	SUMNER	202	2	AGCO-30-100000	3	3	73181	59242	81			
2015-16	SUMNER	202	2	AGCO-30-100000	4	3	57499	48787	85			
2015-16	SUMNER	203	2	AGCO-20-100000	1	3	44431	33977	76	45	23.40	42.64
2015-16	SUMNER	203	2	AGCO-20-100000	2	3	73181	62726	86			
2015-16	SUMNER	203	2	AGCO-20-100000	3	3	65340	52272	80			
2015-16	SUMNER	203	2	AGCO-20-100000	4	3	60113	54886	91			
2015-16	SUMNER	204	2	AGCO-30-150000	1	3	66211	48787	74	40	24.20	43.43
2015-16	SUMNER	204	2	AGCO-30-150000	2	3	76666	60984	80			
2015-16	SUMNER	204	2	AGCO-30-150000	3	3	76666	60984	80			
2015-16	SUMNER	204	2	AGCO-30-150000	4	3	85378	52272	61			
2015-16	SUMNER	205	2	AGCO-20-150000	1	3	88862	70567	79	40	23.92	40.86
2015-16	SUMNER	205	2	AGCO-20-150000	2	3	114998	96703	84			
2015-16	SUMNER	205	2	AGCO-20-150000	3	3	94090	78408	83			
2015-16	SUMNER	205	2	AGCO-20-150000	4	3	81022	73181	90			
2015-16	SUMNER	206	2	AGCO-30-200000	1	4	97574	71438	73	30	23.40	40.99
2015-16	SUMNER	206	2	AGCO-30-200000	2	4	80150	74923	93			
2015-16	SUMNER	206	2	AGCO-30-200000	3	4	78408	57499	73			
2015-16	SUMNER	206	2	AGCO-30-200000	4	4	81893	64469	79			
2015-16	SUMNER	207	2	FARMER-15-562500	1	3	142877	142877	100	30	20.53	42.74
2015-16	SUMNER	207	2	FARMER-15-562500	2	3	195149	156816	80			
2015-16	SUMNER	207	2	FARMER-15-562500	3	3	195149	153331	79			
2015-16	SUMNER	207	2	FARMER-15-562500	4	3	257875	163786	64			
2015-16	SUMNER	208	2	FARMER-15-562500	1	4	243936	160301	66	30	21.66	43.01
2015-16	SUMNER	208	2	FARMER-15-562500	2	4	243936	177725	73			
2015-16	SUMNER	208	2	FARMER-15-562500	3	4	226512	132422	58			

2015-16	SUMNER	208	2	FARMER-15-562500	4	4	191664	142877	75			
2015-16	SUMNER	209	2	FARMER-15-562500	1	3	181210	146362	81	30	21.38	43.6
2015-16	SUMNER	209	2	FARMER-15-562500	2	3	188179	181210	96			
2015-16	SUMNER	209	2	FARMER-15-562500	3	3	174240	153331	88			
2015-16	SUMNER	209	2	FARMER-15-562500	4	3	226512	139392	62			
2015-16	SUMNER	301	3	AGCO-20-150000	1	4	65340	52272	80	40	23.35	39.8
2015-16	SUMNER	301	3	AGCO-20-150000	2	4	44431	41818	94			
2015-16	SUMNER	301	3	AGCO-20-150000	3	4	86249	54886	64			
2015-16	SUMNER	301	3	AGCO-20-150000	4	4	73181	70567	96			
2015-16	SUMNER	302	3	AGCO-30-100000	1	3	41818	29621	71	35	22.37	42.68
2015-16	SUMNER	302	3	AGCO-30-100000	2	3	31363	24394	78			
2015-16	SUMNER	302	3	AGCO-30-100000	3	3	36590	34848	95			
2015-16	SUMNER	302	3	AGCO-30-100000	4	3	50530	43560	86			
2015-16	SUMNER	303	3	AGCO-20-100000	1	3	52272	49658	95	40	23.54	39.21
2015-16	SUMNER	303	3	AGCO-20-100000	2	3	36590	31363	86			
2015-16	SUMNER	303	3	AGCO-20-100000	3	3	44431	39204	88			
2015-16	SUMNER	303	3	AGCO-20-100000	4	3	47045	44431	94			
2015-16	SUMNER	304	3	AGCO-30-150000	1	3	71438	50530	71	35	24.67	42.99
2015-16	SUMNER	304	3	AGCO-30-150000	2	3	55757	47045	84			
2015-16	SUMNER	304	3	AGCO-30-150000	3	3	48787	41818	86			
2015-16	SUMNER	304	3	AGCO-30-150000	4	3	60984	59242	97			
2015-16	SUMNER	305	3	AGCO-20-200000	1	3	107158	94090	88	45	24.62	39.71
2015-16	SUMNER	305	3	AGCO-20-200000	2	3	91476	70567	77			
2015-16	SUMNER	305	3	AGCO-20-200000	3	3	109771	88862	81			
2015-16	SUMNER	305	3	AGCO-20-200000	4	3	94090	83635	89			
2015-16	SUMNER	306	3	AGCO-30-200000	1	3	85378	59242	69	30	24.15	42.77
2015-16	SUMNER	306	3	AGCO-30-200000	2	3	113256	52272	46			
2015-16	SUMNER	306	3	AGCO-30-200000	3	3	106286	74923	70			
2015-16	SUMNER	306	3	AGCO-30-200000	4	3	85378	60984	71			
2015-16	SUMNER	307	3	FARMER-15-562500	1	3	174240	108029	62			
2015-16	SUMNER	307	3	FARMER-15-562500	2	3	216058	156816	73			
2015-16	SUMNER	307	3	FARMER-15-562500	3	3	181210	125453	69			
2015-16	SUMNER	307	3	FARMER-15-562500	4	3	202118	146362	72			
2015-16	SUMNER	308	3	FARMER-15-562500	1							

2015-16	SUMNER	308	3	FARMER-15-562500	2
2015-16	SUMNER	308	3	FARMER-15-562500	3
2015-16	SUMNER	308	3	FARMER-15-562500	4
2015-16	SUMNER	309	3	FARMER-15-562500	1
2015-16	SUMNER	309	3	FARMER-15-562500	2
2015-16	SUMNER	309	3	FARMER-15-562500	3
2015-16	SUMNER	309	3	FARMER-15-562500	4

Appendix C - SAS Codes: "Genotype and Seeding Rate Interactions for Winter Canola in 30-inch Row Spacing"

```
DM 'LOG; CLEAR; OUTPUT; CLEAR;';
OPTIONS PS = 5000 LS=120 NODATE;

TITLE '2014-2016 Canola AGCO On-farm ANOVA';

PROC IMPORT
  DATAFILE=;
  DBMS=XLSX
  OUT=RCB REPLACE;
  SHEET=;
  GETNAMES=YES;
RUN;

DATA RCB; SET RCB;
IF LOCATION = "MANNT" THEN DELETE;
IF LOCATION = "HUTCHNT" THEN DELETE;
IF LOCATION = "HUTVT" THEN DELETE;
IF GENOTYPE = "RILEY" THEN DELETE;
IF GENOTYPE = "DKW44-10" THEN DELETE;
IF GENOTYPE = "MERCEDES" THEN DELETE;
IF GENOTYPE = "SAFRAN" THEN DELETE;
IF TYPE = "OP" THEN DELETE;
IF TYPE = "HYB" THEN DELETE;
RUN;

PROC SORT DATA=RCB; BY LOCATION;
RUN;

PROC PRINT DATA=RCB;
RUN;

PROC GLIMMIX DATA=RCB; TITLE 'MANNT WITH GENOTYPE RCB SPLIT PLOT';
CLASS GENOTYPE SR; BY LOCATION;
MODEL OIL = GENOTYPE SR GENOTYPE*SR/DDFM=SATTERTH;
RANDOM BLOCK BLOCK*SR;
LSMEANS GENOTYPE/LINES ALPHA = 0.1;
LSMEANS SR/LINES ALPHA = 0.1;
LSMEANS GENOTYPE*SR/LINES ALPHA = 0.1;
RUN;

PROC GLIMMIX DATA=RCB; TITLE 'MANNT WITH TYPE RCB SPLIT PLOT';
CLASS TYPE SR; BY LOCATION;
MODEL OIL = TYPE SR TYPE*SR/DDFM=SATTERTH;
RANDOM BLOCK BLOCK*SR;
LSMEANS TYPE/LINES ALPHA = 0.1;
LSMEANS SR/LINES ALPHA = 0.1;
LSMEANS TYPE*SR/LINES ALPHA = 0.1;
```

```
PROC GLIMMIX DATA=RCB; TITLE 'MANNT WITH CROP RCB SPLIT PLOT';
CLASS CROP SR; BY LOCATION;
MODEL OIL = CROP SR CROP*SR/DDFM=SATTERTH;
RANDOM BLOCK BLOCK*SR;
LSMEANS CROP/LINES ALPHA = 0.1;
LSMEANS SR/LINES ALPHA = 0.1;
LSMEANS CROP*SR/LINES ALPHA = 0.1;

DATA RCB; SET RCB;
PSQ = SR*SR;
PCUBE = SR*SR*SR;
RUN;

PROC PRINT DATA=RCB; TITLE 'RAW DATA';
RUN;

PROC REG DATA=RCB; TITLE2 'REGRESSION ANALYSIS-linear model';
  MODEL BU_ACRE = SR/ R CLI CLM;
RUN;

PROC REG DATA=RCB; TITLE2 'REGRESSION ANALYSIS-quadratic model';
  MODEL BU_ACRE = SR PSQ/ R CLI CLM;
RUN;

PROC REG DATA=RCB; TITLE2 'REGRESSION ANALYSIS-cubic model';
  MODEL BU_ACRE = SR PSQ PCUBE/ R CLI CLM;
RUN;


PROC GLIMMIX DATA=RCB; TITLE 'HUTCH WITH GENOTYPE RCB FACTORIAL';
CLASS GENOTYPE SR; BY LOCATION;
MODEL SPRING_STAND_PER_ACRE = GENOTYPE SR GENOTYPE*SR/DDFM=SATTERTH;
RANDOM BLOCK;
LSMEANS GENOTYPE/LINES ALPHA = 0.1;
LSMEANS SR/LINES ALPHA = 0.1;
LSMEANS GENOTYPE*SR/LINES ALPHA = 0.1;
RUN;

PROC GLIMMIX DATA=RCB; TITLE 'HUTCH WITH TYPE RCB FACTORIAL';
CLASS TYPE SR; BY LOCATION;
MODEL BLOOM = TYPE SR TYPE*SR/DDFM=SATTERTH;
RANDOM BLOCK;
LSMEANS TYPE/LINES ALPHA = 0.1;
LSMEANS SR/LINES ALPHA = 0.1;
LSMEANS TYPE*SR/LINES ALPHA = 0.1;

RUN;


DATA RCB; SET RCB;
 IF LOCATION = "MANNT" THEN PYIELD = (YIELD/38.0839)*100;
 IF LOCATION = "HUTCHNT" THEN PYIELD = (YIELD/41.382)*100;
 IF LOCATION = "HUTVT" THEN PYIELD = (YIELD/50.6385)*100;
RUN;

PROC SORT; BY PLOT;
RUN;
```

```
PROC MEANS DATA=RCB NOPRINT MEAN; BY PLOT;
  VAR FALL_STAND_PER_ACRE SPRING_STAND_PER_ACRE WS PYIELD YIELD;
 OUTPUT OUT=PLOTMEANS MEAN=;
RUN;

DATA PLOTMEANS; SET PLOTMEANS;
 LOC = "HUTNT";
 IF PLOT<900 THEN LOC="HUTVT";
 IF PLOT<500 THEN LOC="MANNT";
RUN;

PROC SORT; BY LOC;
RUN;

PROC PRINT DATA=PLOTMEANS;
RUN;

PROC CORR DATA=PLOTMEANS; *BY LOC;
 VAR FALL_STAND_PER_ACRE SPRING_STAND_PER_ACRE WS PYIELD YIELD;
RUN;
```

Appendix D - Raw Data: "Genotype and Seeding Rate Interactions for Winter Canola in 30-inch Row Spacing"

Year	Location	Plot	Block	Sub-sample	Genotype	Seeding rate	Fall stand $acre^{-1}$	Spring stand $acre^{-1}$	Winter survival	Bloom percent	Percent oil	Yield
2015-16	MANNT	101	1	1	Mercedes	400000	165523	69042	42	45	36.36	23.0
2015-16	MANNT	101	1	2	Mercedes	400000	131002	90285	69			
2015-16	MANNT	102	1	1	Safran	400000	119495	69042	58	40	37.22	17.7
2015-16	MANNT	102	1	2	Safran	400000	144279	84974	59			
2015-16	MANNT	103	1	1	Riley	400000	66386	53109	80	40	38.93	21.1
2015-16	MANNT	103	1	2	Riley	400000	75238	58420	78			
2015-16	MANNT	104	1	1	DKW44-10	400000	100907	69042	68	50	35.94	16.0
2015-16	MANNT	104	1	2	DKW44-10	400000	106218	84974	80			
2015-16	MANNT	105	1	1	DKW44-10	100000	53109	53109	100	45	34.3	13.9
2015-16	MANNT	105	1	2	DKW44-10	100000	25669	15933	62			
2015-16	MANNT	106	1	1	Mercedes	100000	37176	37176	100	40	38.99	19.3
2015-16	MANNT	106	1	2	Mercedes	100000	61075	47798	78			
2015-16	MANNT	107	1	1	Riley	100000	45143	42487	94	45	38.66	27.1
2015-16	MANNT	107	1	2	Riley	100000	29210	21244	73			
2015-16	MANNT	108	1	1	Safran	100000	38947	31865	82	45	39.11	20.7
2015-16	MANNT	108	1	2	Safran	100000	37176	37176	100			
2015-16	MANNT	109	1	1	Safran	325000	31865	26554	83	45	36.78	15.4
2015-16	MANNT	109	1	2	Safran	325000	0	0	0			
2015-16	MANNT	110	1	1	DKW44-10	325000	82319	69042	84	40	33.62	
2015-16	MANNT	110	1	2	DKW44-10	325000	106218	74353	70			
2015-16	MANNT	111	1	1	Mercedes	325000	118610	69042	58	45	40.98	23.0
2015-16	MANNT	111	1	2	Mercedes	325000	91170	58420	64			

2015-16	MANNT	112	1	1	Riley	325000	75238	47798	64	45	40.21	19.6
2015-16	MANNT	112	1	2	Riley	325000	53109	42487	80			
2015-16	MANNT	113	1	1	Mercedes	250000	107988	79663	74	50	37.33	19.7
2015-16	MANNT	113	1	2	Mercedes	250000	107103	69042	64			
2015-16	MANNT	114	1	1	Safran	250000	100907	74353	74	50	36.89	17.9
2015-16	MANNT	114	1	2	Safran	250000	97366	74353	76			
2015-16	MANNT	115	1	1	DKW44-10	250000	69927	69042	99	55	34.96	16.0
2015-16	MANNT	115	1	2	DKW44-10	250000	94711	58420	62			
2015-16	MANNT	116	1	1	Riley	250000	82319	53109	65	50	41.5	27.1
2015-16	MANNT	116	1	2	Riley	250000	76123	53109	70			
2015-16	MANNT	117	1	1	DKW44-10	175000	70812	58420	83	45	34.46	15.3
2015-16	MANNT	117	1	2	DKW44-10	175000	42487	37176	88			
2015-16	MANNT	118	1	1	Riley	175000	34521	26554	77	45	40.44	23.3
2015-16	MANNT	118	1	2	Riley	175000	50454	47798	95			
2015-16	MANNT	119	1	1	Mercedes	175000	82319	63731	77	45	41.41	22.8
2015-16	MANNT	119	1	2	Mercedes	175000	35406	31865	90			
2015-16	MANNT	120	1	1	Safran	175000	63731	42487	67	40	41.31	27.7
2015-16	MANNT	120	1	2	Safran	175000	80549	58420	73			
2015-16	MANNT	201	2	1	Mercedes	175000	65501	37176	57	45	38.19	17.1
2015-16	MANNT	201	2	2	Mercedes	175000	66386	53109	80			
2015-16	MANNT	202	2	1	Safran	175000	73467	42487	58	40	35.95	18.9
2015-16	MANNT	202	2	2	Safran	175000	89400	63731	71			
2015-16	MANNT	203	2	1	DKW44-10	175000	39832	31865	80	45	38.08	23.5
2015-16	MANNT	203	2	2	DKW44-10	175000	109759	63731	58			
2015-16	MANNT	204	2	1	Riley	175000	26554	21244	80	45	41.09	18.2
2015-16	MANNT	204	2	2	Riley	175000	21244	21244	100			
2015-16	MANNT	205	2	1	Mercedes	100000	58420	37176	64	40	38.41	26.4
2015-16	MANNT	205	2	2	Mercedes	100000	59305	47798	81			
2015-16	MANNT	206	2	1	Safran	100000	56650	37176	66	40	39.61	19.7
2015-16	MANNT	206	2	2	Safran	100000	36291	31865	88			
2015-16	MANNT	207	2	1	DKW44-10	100000	60190	47798	79	40	37.54	25.5
2015-16	MANNT	207	2	2	DKW44-10	100000	26554	26554	100			
2015-16	MANNT	208	2	1	Riley	100000	23899	10622	44	40	40.97	25.2
2015-16	MANNT	208	2	2	Riley	100000	48683	42487	87			

2015-16	MANNT	209	2	1	Mercedes	325000	153131	95596	62	45	38.6	21.1
2015-16	MANNT	209	2	2	Mercedes	325000	136313	58420	43			
2015-16	MANNT	210	2	1	DKW44-10	325000	167293	74353	44	45	32.72	12.7
2015-16	MANNT	210	2	2	DKW44-10	325000	128347	84974	66			
2015-16	MANNT	211	2	1	Riley	325000	87630	58420	67	40	40.08	21.6
2015-16	MANNT	211	2	2	Riley	325000	103563	69042	67			
2015-16	MANNT	212	2	1	Safran	325000	91170	63731	70	45	40.73	31.2
2015-16	MANNT	212	2	2	Safran	325000	66386	47798	72			
2015-16	MANNT	213	2	1	Mercedes	400000	139854	84974	61	50	30.59	17.6
2015-16	MANNT	213	2	2	Mercedes	400000	130117	95596	73			
2015-16	MANNT	214	2	1	DKW44-10	400000	174375	90285	52	45	37.85	
2015-16	MANNT	214	2	2	DKW44-10	400000	170834	42487	25			
2015-16	MANNT	215	2	1	Riley	400000	114184	90285	79	45	42.54	22.5
2015-16	MANNT	215	2	2	Riley	400000	131002	69042	53			
2015-16	MANNT	216	2	1	Safran	400000	139854	84974	61	50	39.79	20.1
2015-16	MANNT	216	2	2	Safran	400000	151361	111529	74			
2015-16	MANNT	217	2	1	DKW44-10	250000	117725	69042	59	45	33.25	26.0
2015-16	MANNT	217	2	2	DKW44-10	250000	128347	79663	62			
2015-16	MANNT	218	2	1	Mercedes	250000	115955	79663	69	45	36.62	33.7
2015-16	MANNT	218	2	2	Mercedes	250000	101792	74353	73			
2015-16	MANNT	219	2	1	Safran	250000	131887	74353	56	45	41.24	26.8
2015-16	MANNT	219	2	2	Safran	250000	75238	69042	92			
2015-16	MANNT	220	2	1	Riley	250000	93826	58420	62	45	41.93	29.7
2015-16	MANNT	220	2	2	Riley	250000	78778	74353	94			
2015-16	MANNT	301	3	1	Mercedes	250000	87630	63731	73	45	37.73	18.5
2015-16	MANNT	301	3	2	Mercedes	250000	106218	100907	95			
2015-16	MANNT	302	3	1	Safran	250000	84089	58420	69	50	36.27	18.0
2015-16	MANNT	302	3	2	Safran	250000	104448	79663	76			
2015-16	MANNT	303	3	1	DKW44-10	250000	96481	58420	61	45	35.04	19.4
2015-16	MANNT	303	3	2	DKW44-10	250000	109759	100907	92			
2015-16	MANNT	304	3	1	Riley	250000	77008	69042	90	45	41.08	25.1
2015-16	MANNT	304	3	2	Riley	250000	81434	63731	78			
2015-16	MANNT	305	3	1	DKW44-10	100000	37176	37176	100	40		18.0
2015-16	MANNT	305	3	2	DKW44-10	100000	36291	31865	88			

2015-16	MANNT	306	3	1	Riley	100000	7081			40	36.39	26.7
2015-16	MANNT	306	3	2	Riley	100000	37176	31865	86			
2015-16	MANNT	307	3	1	Mercedes	100000	37176	37176	100	45	36.39	31.5
2015-16	MANNT	307	3	2	Mercedes	100000	47798	47798	100			
2015-16	MANNT	308	3	1	Safran	100000	47798	47798	100	40	38.24	25.5
2015-16	MANNT	308	3	2	Safran	100000	38061	31865	84			
2015-16	MANNT	309	3	1	Mercedes	175000	28325	26554	94	40	42.46	14.3
2015-16	MANNT	309	3	2	Mercedes	175000	53994	53109	98			
2015-16	MANNT	310	3	1	Safran	175000	56650	47798	84	45	40.33	18.0
2015-16	MANNT	310	3	2	Safran	175000	89400	26554	30			
2015-16	MANNT	311	3	1	Riley	175000	40717	37176	91	40	37.76	30.2
2015-16	MANNT	311	3	2	Riley	175000	68157	47798	70			
2015-16	MANNT	312	3	1	DKW44-10	175000	84089	74353	88	40	40.3	18.7
2015-16	MANNT	312	3	2	DKW44-10	175000	38061	37176	98			
2015-16	MANNT	313	3	1	Riley	325000	85860	69042	80	50	36.25	19.1
2015-16	MANNT	313	3	2	Riley	325000	119495	79663	67			
2015-16	MANNT	314	3	1	Mercedes	325000	149590	100907	67	50	38.43	24.5
2015-16	MANNT	314	3	2	Mercedes	325000	118610	106218	90			
2015-16	MANNT	315	3	1	Safran	325000	124806	63731	51	50	39.35	33.4
2015-16	MANNT	315	3	2	Safran	325000	116840	84974	73			
2015-16	MANNT	316	3	1	DKW44-10	325000	162868	84974	52	50	38.94	20.0
2015-16	MANNT	316	3	2	DKW44-10	325000	77893	58420	75			
2015-16	MANNT	317	3	1	DKW44-10	400000	162868	95596	59	50	37.19	
2015-16	MANNT	317	3	2	DKW44-10	400000	144279	79663	55			
2015-16	MANNT	318	3	1	Safran	400000	123036	79663	65	45	35.63	
2015-16	MANNT	318	3	2	Safran	400000	124806	84974	68			
2015-16	MANNT	319	3	1	Riley	400000	121266	74353	61	45	33.21	
2015-16	MANNT	319	3	2	Riley	400000	118610	74353	63			
2015-16	MANNT	320	3	1	Mercedes	400000	169064	90285	53	50	35.06	31.0
2015-16	MANNT	320	3	2	Mercedes	400000	173489	90285	52			
2015-16	MANNT	401	4	1	Safran	175000	59305	37176	63	40	43.37	25.3
2015-16	MANNT	401	4	2	Safran	175000	73467	63731	87			
2015-16	MANNT	402	4	1	DKW44-10	175000	90285	47798	53	40	36.43	24.2
2015-16	MANNT	402	4	2	DKW44-10	175000	63731	37176	58			

2015-16	MANNT	403	4	1	Riley	175000	35406	31865	90	40	34.91	30.0
2015-16	MANNT	403	4	2	Riley	175000	26554	26554	100			
2015-16	MANNT	404	4	1	Mercedes	175000	33636	31865	95	45	39.62	30.1
2015-16	MANNT	404	4	2	Mercedes	175000	81434	69042	85			
2015-16	MANNT	405	4	1	Mercedes	250000	69042	47798	69	45	41.3	19.5
2015-16	MANNT	405	4	2	Mercedes	250000	118610	90285	76			
2015-16	MANNT	406	4	1	DKW44-10	250000	133658	69042	52	45	37.69	20.8
2015-16	MANNT	406	4	2	DKW44-10	250000	105333	90285	86			
2015-16	MANNT	407	4	1	Safran	250000	72582	47798	66	45	33.48	25.5
2015-16	MANNT	407	4	2	Safran	250000	71697	53109	74			
2015-16	MANNT	408	4	1	Riley	250000	42487	37176	88	45	37.68	33.9
2015-16	MANNT	408	4	2	Riley	250000	69042	58420	85			
2015-16	MANNT	409	4	1	Riley	100000	35406	31865	90	40	40.32	34.0
2015-16	MANNT	409	4	2	Riley	100000	34521	15933	46			
2015-16	MANNT	410	4	1	Safran	100000	51339	26554	52	45	37.81	26.4
2015-16	MANNT	410	4	2	Safran	100000	34521	26554	77			
2015-16	MANNT	411	4	1	DKW44-10	100000	47798	47798	100	45	35.59	29.7
2015-16	MANNT	411	4	2	DKW44-10	100000	31865	21244	67			
2015-16	MANNT	412	4	1	Mercedes	100000	28325	26554	94	45	35.47	36.0
2015-16	MANNT	412	4	2	Mercedes	100000	90285	31865	35			
2015-16	MANNT	413	4	1	Riley	325000	76123	53109	70	45	38.9	23.4
2015-16	MANNT	413	4	2	Riley	325000	69927	58420	84			
2015-16	MANNT	414	4	1	DKW44-10	325000	150475	63731	42	45	32.75	18.8
2015-16	MANNT	414	4	2	DKW44-10	325000	107988	69042	64			
2015-16	MANNT	415	4	1	Safran	325000	128347	58420	46	50		27.9
2015-16	MANNT	415	4	2	Safran	325000	125691	90285	72			
2015-16	MANNT	416	4	1	Mercedes	325000	143394	79663	56	45	38.36	20.2
2015-16	MANNT	416	4	2	Mercedes	325000	119495	69042	58			
2015-16	MANNT	417	4	1	DKW44-10	400000	107103	69042	64	50	35.44	21.9
2015-16	MANNT	417	4	2	DKW44-10	400000	150475	111529	74			
2015-16	MANNT	418	4	1	Mercedes	400000	175260	79663	45	45	35.05	25.9
2015-16	MANNT	418	4	2	Mercedes	400000	143394	95596	67			
2015-16	MANNT	419	4	1	Safran	400000	142509	69042	48	50	37.81	30.3
2015-16	MANNT	419	4	2	Safran	400000	158442	95596	60			

2015-16	MANNT	420	4	1	Riley	400000	92056	47798	52	50	35.05	41.9
2015-16	MANNT	420	4	2	Riley	400000	85860	58420	68			
2015-16	HUTVT	501	1	1	RILEY	400000	58420	42487	73	60	37.81	36.0
2015-16	HUTVT	501	1	2	RILEY	400000	47798	37176	78			
2015-16	HUTVT	502	1	1	DKW44-10	250000	100907	90285	89	60	39.47	37.3
2015-16	HUTVT	502	1	2	DKW44-10	250000	74353	90285	121			
2015-16	HUTVT	503	1	1	MERCEDES	100000	90285	74353	82	55	37.73	35.7
2015-16	HUTVT	503	1	2	MERCEDES	100000	90285	90285	100			
2015-16	HUTVT	504	1	1	DKW44-10	175000	53109	53109	100	50	40.37	29.1
2015-16	HUTVT	504	1	2	DKW44-10	175000	69042	42487	62			
2015-16	HUTVT	505	1	1	MERCEDES	175000	132772	90285	68	55	39.23	26.8
2015-16	HUTVT	505	1	2	MERCEDES	175000	79663	69042	87			
2015-16	HUTVT	506	1	1	RILEY	100000	74353	69042	93	65	38.14	30.1
2015-16	HUTVT	506	1	2	RILEY	100000	74353	53109	71			
2015-16	HUTVT	507	1	1	SAFRAN	175000	63731	31865	50	55	37.32	44.8
2015-16	HUTVT	507	1	2	SAFRAN	175000	84974	26554	31			
2015-16	HUTVT	508	1	1	RILEY	175000	159327	74353	47	55		55.7
2015-16	HUTVT	508	1	2	RILEY	175000	69042	69042	100			
2015-16	HUTVT	509	1	1	MERCEDES	400000	100907	100907	100	60	34.31	31.2
2015-16	HUTVT	509	1	2	MERCEDES	400000	95596	58420	61			
2015-16	HUTVT	510	1	1	MERCEDES	250000	63731	58420	92	65	34.17	36.9
2015-16	HUTVT	510	1	2	MERCEDES	250000	180571	63731	35			
2015-16	HUTVT	511	1	1	SAFRAN	325000	79663	69042	87	50	39,98	43.0
2015-16	HUTVT	511	1	2	SAFRAN	325000	95596	53109	56			
2015-16	HUTVT	512	1	1	SAFRAN	100000	95596	42487	44	60	38.12	34.4
2015-16	HUTVT	512	1	2	SAFRAN	100000	159327	37176	23			
2015-16	HUTVT	513	1	1	MERCEDES	325000	47798	42487	89	50	35.93	44.0
2015-16	HUTVT	513	1	2	MERCEDES	325000	37176	37176	100			
2015-16	HUTVT	514	1	1	DKW44-10	325000	58420	53109	91	55	40.51	35.5
2015-16	HUTVT	514	1	2	DKW44-10	325000	79663	79663	100			
2015-16	HUTVT	515	1	1	SAFRAN	400000	58420	47798	82	55	37.09	41.8
2015-16	HUTVT	515	1	2	SAFRAN	400000	143394	42487	30			
2015-16	HUTVT	516	1	1	RILEY	250000	53109	42487	80	55	37.45	35.2
2015-16	HUTVT	516	1	2	RILEY	250000	47798	42487	89			

2015-16	HUTVT	517	1	1	DKW44-10	100000	69042	58420	85	60	37.06	41.3
2015-16	HUTVT	517	1	2	DKW44-10	100000	79663	63731	80			
2015-16	HUTVT	518	1	1	DKW44-10	400000	79663	47798	60	60	37.61	45.5
2015-16	HUTVT	518	1	2	DKW44-10	400000	90285	58420	65			
2015-16	HUTVT	519	1	1	RILEY	325000	79663	31865	40	50	39.2	31.0
2015-16	HUTVT	519	1	2	RILEY	325000	90285	21244	24			
2015-16	HUTVT	520	1	1	SAFRAN	250000	53109	31865	60	55	36.28	36.1
2015-16	HUTVT	520	1	2	SAFRAN	250000	69042	47798	69			
2015-16	HUTVT	601	2	1	SAFRAN	325000	84974	42487	50	50	37.95	32.4
2015-16	HUTVT	601	2	2	SAFRAN	325000	79663	53109	67			
2015-16	HUTVT	602	2	1	DKW44-10	175000	106218	63731	60	65	40.58	44.9
2015-16	HUTVT	602	2	2	DKW44-10	175000	138083	79663	58			
2015-16	HUTVT	603	2	1	MERCEDES	400000	84974	79663	94	55	37.72	37.3
2015-16	HUTVT	603	2	2	MERCEDES	400000	84974	90285	106			
2015-16	HUTVT	604	2	1	DKW44-10	400000	47798	37176	78	45	38.98	29.6
2015-16	HUTVT	604	2	2	DKW44-10	400000	53109	47798	90			
2015-16	HUTVT	605	2	1	DKW44-10	325000	26554	21244	80	45	37.42	25.0
2015-16	HUTVT	605	2	2	DKW44-10	325000	21244	21244	100			
2015-16	HUTVT	606	2	1	MERCEDES	100000	53109	53109	100	55	35.81	44.7
2015-16	HUTVT	606	2	2	MERCEDES	100000	26554	26554	100			
2015-16	HUTVT	607	2	1	SAFRAN	100000	58420	53109	91	60	40.09	55.6
2015-16	HUTVT	607	2	2	SAFRAN	100000	69042	42487	62			
2015-16	HUTVT	608	2	1	DKW44-10	250000	63731	31865	50	50	38.79	22.5
2015-16	HUTVT	608	2	2	DKW44-10	250000	84974	37176	44			
2015-16	HUTVT	609	2	1	RILEY	100000	90285	90285	100	45	41.96	18.8
2015-16	HUTVT	609	2	2	RILEY	100000	116840	95596	82			
2015-16	HUTVT	610	2	1	SAFRAN	175000	106218	84974	80	45	40.32	21.7
2015-16	HUTVT	610	2	2	SAFRAN	175000	100907	100907	100			
2015-16	HUTVT	611	2	1	MERCEDES	325000	106218	84974	80	40	35.65	17.9
2015-16	HUTVT	611	2	2	MERCEDES	325000	106218	79663	75			
2015-16	HUTVT	612	2	1	RILEY	175000	111529	63731	57	40	36.37	28.4
2015-16	HUTVT	612	2	2	RILEY	175000	164638	90285	55			
2015-16	HUTVT	613	2	1	MERCEDES	250000	148705	116840	79	50	41.22	30.8
2015-16	HUTVT	613	2	2	MERCEDES	250000	159327	100907	63			

2015-16	HUTVT	614	2	1	SAFRAN	400000	31865	31865	100	50	36.16	31.4
2015-16	HUTVT	614	2	2	SAFRAN	400000	53109	42487	80			
2015-16	HUTVT	615	2	1	RILEY	400000	63731	63731	100	50	37.31	29.1
2015-16	HUTVT	615	2	2	RILEY	400000	84974	90285	106			
2015-16	HUTVT	616	2	1	SAFRAN	250000	79663	53109	67	60	35.89	33.5
2015-16	HUTVT	616	2	2	SAFRAN	250000	148705	53109	36			
2015-16	HUTVT	617	2	1	RILEY	325000	74353	69042	93	55	36.8	41.7
2015-16	HUTVT	617	2	2	RILEY	325000	90285	37176	41			
2015-16	HUTVT	618	2	1	DKW44-10	100000	143394	111529	78	55	35.06	31.6
2015-16	HUTVT	618	2	2	DKW44-10	100000	106218	84974	80			
2015-16	HUTVT	619	2	1	MERCEDES	175000	159327	53109	33	55	37.95	31.4
2015-16	HUTVT	619	2	2	MERCEDES	175000	111529	47798	43			
2015-16	HUTVT	620	2	1	RILEY	250000	58420	.	.	50	38.65	28.5
2015-16	HUTVT	620	2	2	RILEY	250000	79663	47798	60			
2015-16	HUTVT	701	3	1	RILEY	100000	132772	84974	64	50	35.12	49.0
2015-16	HUTVT	701	3	2	RILEY	100000	143394	111529	78			
2015-16	HUTVT	702	3	1	DKW44-10	400000	100907	58420	58	50	36.1	34.4
2015-16	HUTVT	702	3	2	DKW44-10	400000	69042	58420	85			
2015-16	HUTVT	703	3	1	SAFRAN	100000	42487	42487	100	45	38.57	36.9
2015-16	HUTVT	703	3	2	SAFRAN	100000	26554	26554	100			
2015-16	HUTVT	704	3	1	SAFRAN	175000	90285	74353	82	45	37.29	28.7
2015-16	HUTVT	704	3	2	SAFRAN	175000	79663	42487	53			
2015-16	HUTVT	705	3	1	RILEY	400000	84974	84974	100	45	41.59	44.6
2015-16	HUTVT	705	3	2	RILEY	400000	58420	42487	73			
2015-16	HUTVT	706	3	1	MERCEDES	100000	53109	53109	100	40	39.29	35.4
2015-16	HUTVT	706	3	2	MERCEDES	100000	53109	53109	100			
2015-16	HUTVT	707	3	1	RILEY	175000	53109	42487	80	40	36.14	30.3
2015-16	HUTVT	707	3	2	RILEY	175000	63731					
2015-16	HUTVT	708	3	1	RILEY	250000	90285	63731	71	50	31.73	36.4
2015-16	HUTVT	708	3	2	RILEY	250000	90285	69042	76			
2015-16	HUTVT	709	3	1	DKW44-10	175000	95596	74353	78	45	38.08	21.7
2015-16	HUTVT	709	3	2	DKW44-10	175000	63731					
2015-16	HUTVT	710	3	1	SAFRAN	400000	69042	63731	92	40	38.33	22.9
2015-16	HUTVT	710	3	2	SAFRAN	400000	132772	63731	48			

2015-16	HUTVT	711	3	1	MERCEDES	325000	58420	37176	64	45	38.98	22.9
2015-16	HUTVT	711	3	2	MERCEDES	325000	63731	58420	92			
2015-16	HUTVT	712	3	1	MERCEDES	250000	69042	42487	62	50	36.65	34.9
2015-16	HUTVT	712	3	2	MERCEDES	250000	79663	42487	53			
2015-16	HUTVT	713	3	1	MERCEDES	400000	58420	53109	91	50	37.76	25.1
2015-16	HUTVT	713	3	2	MERCEDES	400000	69042	58420	85			
2015-16	HUTVT	714	3	1	DKW44-10	325000	106218	53109	50	45		33.9
2015-16	HUTVT	714	3	2	DKW44-10	325000	138083	31865	23			
2015-16	HUTVT	715	3	1	DKW44-10	250000	69042	47798	69	45	32	25.4
2015-16	HUTVT	715	3	2	DKW44-10	250000	53109	42487	80			
2015-16	HUTVT	716	3	1	DKW44-10	100000	95596	42487	44	55	37.93	47.5
2015-16	HUTVT	716	3	2	DKW44-10	100000	84974	58420	69			
2015-16	HUTVT	717	3	1	RILEY	325000	69042	69042	100	50	34.49	38.9
2015-16	HUTVT	717	3	2	RILEY	325000	79663	74353	93			
2015-16	HUTVT	718	3	1	SAFRAN	325000	84974	79663	94	50	32.96	38.0
2015-16	HUTVT	718	3	2	SAFRAN	325000	106218	84974	80			
2015-16	HUTVT	719	3	1	MERCEDES	175000	185881	58420	31	50	34	34.4
2015-16	HUTVT	719	3	2	MERCEDES	175000	84974	79663	94			
2015-16	HUTVT	720	3	1	SAFRAN	250000	116840	53109	45	60	41.45	44.1
2015-16	HUTVT	720	3	2	SAFRAN	250000	191192	84974	44			
2015-16	HUTVT	801	4	1	RILEY	250000	31865	26554	83	40	36.62	47.7
2015-16	HUTVT	801	4	2	RILEY	250000	31865	21244	67			
2015-16	HUTVT	802	4	1	SAFRAN	400000	159327	63731	40	55	39.72	44.4
2015-16	HUTVT	802	4	2	SAFRAN	400000	79663	74353	93			
2015-16	HUTVT	803	4	1	DKW44-10	400000	100907	53109	53	45	33.82	39.5
2015-16	HUTVT	803	4	2	DKW44-10	400000	63731	58420	92			
2015-16	HUTVT	804	4	1	SAFRAN	175000	74353	53109	71	45	36.89	37.3
2015-16	HUTVT	804	4	2	SAFRAN	175000	74353	53109	71			
2015-16	HUTVT	805	4	1	MERCEDES	175000	90285	69042	76	45	35.69	23.0
2015-16	HUTVT	805	4	2	MERCEDES	175000	111529	69042	62			
2015-16	HUTVT	806	4	1	SAFRAN	325000	95596	69042	72	50	38.76	49.0
2015-16	HUTVT	806	4	2	SAFRAN	325000	95596	58420	61			
2015-16	HUTVT	807	4	1	MERCEDES	325000	79663	53109	67	45	37.22	36.1
2015-16	HUTVT	807	4	2	MERCEDES	325000	90285	47798	53			

2015-16	HUTVT	808	4	1	MERCEDES	400000	84974	53109	63	45	34.81	36.9
2015-16	HUTVT	808	4	2	MERCEDES	400000	90285	69042	76			
2015-16	HUTVT	809	4	1	DKW44-10	250000	69042	63731	92	45	40.02	34.7
2015-16	HUTVT	809	4	2	DKW44-10	250000	84974	58420	69			
2015-16	HUTVT	810	4	1	DKW44-10	325000	84974	74353	88	40	37.23	17.3
2015-16	HUTVT	810	4	2	DKW44-10	325000	106218	42487	40			
2015-16	HUTVT	811	4	1	RILEY	100000	84974	74353	88	45	39.66	43.1
2015-16	HUTVT	811	4	2	RILEY	100000	111529	53109	48			
2015-16	HUTVT	812	4	1	RILEY	175000	63731	53109	83	55	39.35	49.9
2015-16	HUTVT	812	4	2	RILEY	175000	100907	53109	53			
2015-16	HUTVT	813	4	1	RILEY	325000	53109	31865	60	45	41.73	49.8
2015-16	HUTVT	813	4	2	RILEY	325000	84974	37176	44			
2015-16	HUTVT	814	4	1	SAFRAN	100000	26554			60	36.33	39.9
2015-16	HUTVT	814	4	2	SAFRAN	100000	31865	31865	100			
2015-16	HUTVT	815	4	1	MERCEDES	250000	69042	74353	108	60	37.02	31.1
2015-16	HUTVT	815	4	2	MERCEDES	250000	63731	58420	92			
2015-16	HUTVT	816	4	1	DKW44-10	175000	122151	90285	74	60	40.82	47.7
2015-16	HUTVT	816	4	2	DKW44-10	175000	127462	95596	75			
2015-16	HUTVT	817	4	1	DKW44-10	100000	42487	42487	100	65	33.95	35.5
2015-16	HUTVT	817	4	2	DKW44-10	100000	47798	37176	78			
2015-16	HUTVT	818	4	1	MERCEDES	100000	175260	47798	27	45	34.8	39.5
2015-16	HUTVT	818	4	2	MERCEDES	100000	159327	63731	40			
2015-16	HUTVT	819	4	1	RILEY	400000	74353	74353	100	50	34.2	30.7
2015-16	HUTVT	819	4	2	RILEY	400000	95596	53109	56			
2015-16	HUTVT	820	4	1	SAFRAN	250000	74353	47798	64	50	38.15	33.7
2015-16	HUTVT	820	4	2	SAFRAN	250000	106218	42487	40			
2015-16	HUTNT	901	1	1	RILEY	100000	63731	47798	75	70	37.92	45.5
2015-16	HUTNT	901	1	2	RILEY	100000	69042	53109	77			
2015-16	HUTNT	902	1	1	MERCEDES	400000	90285	69042	76	75	36.36	36.6
2015-16	HUTNT	902	1	2	MERCEDES	400000	132772	79663	60			
2015-16	HUTNT	903	1	1	MERCEDES	325000	53109	42487	80	70	40.12	44.8
2015-16	HUTNT	903	1	2	MERCEDES	325000	58420	31865	55			
2015-16	HUTNT	904	1	1	SAFRAN	175000	58420	42487	73	70	37.64	30.2
2015-16	HUTNT	904	1	2	SAFRAN	175000	95596	58420	61			

2015-16	HUTNT	905	1	1	DKW44-10	325000	69042	58420	85	60	43.95	40.5
2015-16	HUTNT	905	1	2	DKW44-10	325000	84974	53109	63			
2015-16	HUTNT	906	1	1	DKW44-10	175000	47798	42487	89	60	39.57	26.4
2015-16	HUTNT	906	1	2	DKW44-10	175000	42487	37176	88			
2015-16	HUTNT	907	1	1	MERCEDES	100000	79663	47798	60	60	40.63	30.5
2015-16	HUTNT	907	1	2	MERCEDES	100000	79663	42487	53			
2015-16	HUTNT	908	1	1	DKW44-10	400000	106218	90285	85	40	40.88	19.6
2015-16	HUTNT	908	1	2	DKW44-10	400000	154016	53109	34			
2015-16	HUTNT	909	1	1	SAFRAN	400000	122151	90285	74	50	40.85	38.4
2015-16	HUTNT	909	1	2	SAFRAN	400000	69042	63731	92			
2015-16	HUTNT	910	1	1	DKW44-10	100000	42487	26554	63	50	40.11	31.8
2015-16	HUTNT	910	1	2	DKW44-10	100000	47798	26554	56			
2015-16	HUTNT	911	1	1	MERCEDES	250000	90285	63731	71	45	36.67	26.9
2015-16	HUTNT	911	1	2	MERCEDES	250000	143394	95596	67			
2015-16	HUTNT	912	1	1	SAFRAN	100000	47798	42487	89	45	35.97	26.1
2015-16	HUTNT	912	1	2	SAFRAN	100000	58420	53109	91			
2015-16	HUTNT	913	1	1	MERCEDES	175000	148705	53109	36	50	42.04	39.3
2015-16	HUTNT	913	1	2	MERCEDES	175000	106218	63731	60			
2015-16	HUTNT	914	1	1	SAFRAN	325000	143394	69042	48	45	35.84	19.7
2015-16	HUTNT	914	1	2	SAFRAN	325000	148705	69042	46			
2015-16	HUTNT	915	1	1	RILEY	250000	58420	37176	64	50	37.31	24.0
2015-16	HUTNT	915	1	2	RILEY	250000	79663	53109	67			
2015-16	HUTNT	916	1	1	RILEY	400000	148705	90285	61	50	36.41	25.9
2015-16	HUTNT	916	1	2	RILEY	400000	116840	84974	73			
2015-16	HUTNT	917	1	1	DKW44-10	250000	69042	69042	100	50	37.2	22.9
2015-16	HUTNT	917	1	2	DKW44-10	250000	63731	53109	83			
2015-16	HUTNT	918	1	1	RILEY	325000	154016	74353	48	45	34.38	17.0
2015-16	HUTNT	918	1	2	RILEY	325000	196503	74353	38			
2015-16	HUTNT	919	1	1	RILEY	175000	58420	53109	91	40	41.38	26.7
2015-16	HUTNT	919	1	2	RILEY	175000	74353	63731	86			
2015-16	HUTNT	920	1	1	SAFRAN	250000	79663	42487	53	40	37.54	27.7
2015-16	HUTNT	920	1	2	SAFRAN	250000	84974	63731	75			
2015-16	HUTNT	1001	2	1	SAFRAN	175000	95596	58420	61	60	36.8	36.3
2015-16	HUTNT	1001	2	2	SAFRAN	175000	79663	53109	67			

2015-16	HUTNT	1002	2	1	MERCEDES	400000	106218	63731	60	70	33.84	27.1
2015-16	HUTNT	1002	2	2	MERCEDES	400000	95596	37176	39			
2015-16	HUTNT	1003	2	1	DKW44-10	175000	106218	58420	55	70	38.34	34.0
2015-16	HUTNT	1003	2	2	DKW44-10	175000	116840	58420	50			
2015-16	HUTNT	1004	2	1	SAFRAN	100000	79663	63731	80	50	32.66	10.5
2015-16	HUTNT	1004	2	2	SAFRAN	100000	79663	74353	93			
2015-16	HUTNT	1005	2	1	RILEY	100000	74353	63731	86	45	36.38	13.7
2015-16	HUTNT	1005	2	2	RILEY	100000	69042	53109	77			
2015-16	HUTNT	1006	2	1	MERCEDES	100000	84974	53109	63	45	39.48	30.8
2015-16	HUTNT	1006	2	2	MERCEDES	100000	74353	26554	36			
2015-16	HUTNT	1007	2	1	MERCEDES	175000	63731	58420	92	45	38.57	28.8
2015-16	HUTNT	1007	2	2	MERCEDES	175000	58420	53109	91			
2015-16	HUTNT	1008	2	1	SAFRAN	400000	106218	79663	75	50	35.54	22.5
2015-16	HUTNT	1008	2	2	SAFRAN	400000	143394	79663	56			
2015-16	HUTNT	1009	2	1	DKW44-10	250000	106218	21244	20	40	37.65	23.5
2015-16	HUTNT	1009	2	2	DKW44-10	250000	100907	31865	32			
2015-16	HUTNT	1010	2	1	MERCEDES	325000	169949	74353	44	50	37.13	26.5
2015-16	HUTNT	1010	2	2	MERCEDES	325000	148705	58420	39			
2015-16	HUTNT	1011	2	1	DKW44-10	325000	143394	106218	74	50	38.81	36.7
2015-16	HUTNT	1011	2	2	DKW44-10	325000	154016	84974	55			
2015-16	HUTNT	1012	2	1	MERCEDES	250000	106218	95596	90	50	34.38	23.9
2015-16	HUTNT	1012	2	2	MERCEDES	250000	138083	106218	77			
2015-16	HUTNT	1013	2	1	RILEY	175000	84974	47798	56	60	40.17	29.7
2015-16	HUTNT	1013	2	2	RILEY	175000	31865	26554	83			
2015-16	HUTNT	1014	2	1	RILEY	250000	95596	74353	78	45	35.59	21.7
2015-16	HUTNT	1014	2	2	RILEY	250000	84974	63731	75			
2015-16	HUTNT	1015	2	1	SAFRAN	325000	106218	53109	50	45	36.86	22.2
2015-16	HUTNT	1015	2	2	SAFRAN	325000	138083	58420	42			
2015-16	HUTNT	1016	2	1	RILEY	325000	111529	63731	57	50	36.34	28.4
2015-16	HUTNT	1016	2	2	RILEY	325000	84974	53109	63			
2015-16	HUTNT	1017	2	1	SAFRAN	250000	122151	47798	39	45	38.98	22.0
2015-16	HUTNT	1017	2	2	SAFRAN	250000	148705	58420	39			
2015-16	HUTNT	1018	2	1	DKW44-10	400000	69042	58420	85	45	36.37	23.3
2015-16	HUTNT	1018	2	2	DKW44-10	400000	95596	53109	56			

2015-16	HUTNT	1019	2	1	DKW44-10	100000	53109	47798	90	60	40.27	39.1
2015-16	HUTNT	1019	2	2	DKW44-10	100000	53109	42487	80			
2015-16	HUTNT	1020	2	1	RILEY	400000	122151	47798	39	50	37.01	29.7
2015-16	HUTNT	1020	2	2	RILEY	400000	116840	37176	32			
2015-16	HUTNT	1101	3	1	DKW44-10	400000	132772	79663	60	45	35.91	24.5
2015-16	HUTNT	1101	3	2	DKW44-10	400000	212436	116840	55			
2015-16	HUTNT	1102	3	1	DKW44-10	175000	47798	47798	100	60	34.32	19.7
2015-16	HUTNT	1102	3	2	DKW44-10	175000	63731	58420	92			
2015-16	HUTNT	1103	3	1	RILEY	100000	31865	31865	100	40	35.62	18.7
2015-16	HUTNT	1103	3	2	RILEY	100000	31865	21244	67			
2015-16	HUTNT	1104	3	1	RILEY	325000	111529	53109	48	45	37.51	27.2
2015-16	HUTNT	1104	3	2	RILEY	325000	106218	79663	75			
2015-16	HUTNT	1105	3	1	MERCEDES	250000	95596	47798	50	45	37.09	17.0
2015-16	HUTNT	1105	3	2	MERCEDES	250000	100907	53109	53			
2015-16	HUTNT	1106	3	1	SAFRAN	100000	63731	53109	83	50	40.09	30.0
2015-16	HUTNT	1106	3	2	SAFRAN	100000	74353	69042	93			
2015-17	HUTNT	1107	3	1	RILEY	250000	95596	37176	39	45	37.4	24.9
2015-16	HUTNT	1107	3	2	RILEY	250000	79663	31865	40			
2015-16	HUTNT	1108	3	1	DKW44-10	100000	37176	26554	71	40	37.69	18.1
2015-16	HUTNT	1108	3	2	DKW44-10	100000	53109	37176	70			
2015-16	HUTNT	1109	3	1	SAFRAN	325000	169949	58420	34	45	36.65	25.5
2015-16	HUTNT	1109	3	2	SAFRAN	325000	132772	63731	48			
2015-16	HUTNT	1110	3	1	SAFRAN	175000	79663	69042	87	45	36.51	17.4
2015-16	HUTNT	1110	3	2	SAFRAN	175000	84974	58420	69			
2015-16	HUTNT	1111	3	1	RILEY	400000	127462	58420	46	45	37.84	21.0
2015-16	HUTNT	1111	3	2	RILEY	400000	148705	63731	43			
2015-16	HUTNT	1112	3	1	MERCEDES	100000	111529	63731	57	45	39.58	20.8
2015-16	HUTNT	1112	3	2	MERCEDES	100000	122151	69042	57			
2015-16	HUTNT	1113	3	1	SAFRAN	400000	132772	53109	40	45	37.17	19.7
2015-16	HUTNT	1113	3	2	SAFRAN	400000	148705	79663	54			
2015-16	HUTNT	1114	3	1	RILEY	175000	69042	53109	77	45	31.34	14.2
2015-16	HUTNT	1114	3	2	RILEY	175000	79663	69042	87			
2015-16	HUTNT	1115	3	1	DKW44-10	325000	111529	31865	29	40	35.25	16.1
2015-16	HUTNT	1115	3	2	DKW44-10	325000	122151	63731	52			

2015-16	HUTNT	1116	3	1	MERCEDES	175000	69042	47798	69	45	36.21	23.4
2015-16	HUTNT	1116	3	2	MERCEDES	175000	69042	37176	54			
2015-16	HUTNT	1117	3	1	SAFRAN	250000	90285	58420	65	45	38.36	24.7
2015-16	HUTNT	1117	3	2	SAFRAN	250000	69042	37176	54			
2015-16	HUTNT	1118	3	1	MERCEDES	400000	127462	69042	54	40	37.54	20.8
2015-16	HUTNT	1118	3	2	MERCEDES	400000	127462	47798	38			
2015-16	HUTNT	1119	3	1	DKW44-10	250000	79663	37176	47	40	38.88	30.0
2015-16	HUTNT	1119	3	2	DKW44-10	250000	74353	53109	71			
2015-16	HUTNT	1120	3	1	MERCEDES	325000	143394	53109	37	45	39.66	22.5
2015-16	HUTNT	1120	3	2	MERCEDES	325000	143394	31865	22			
2015-16	HUTNT	1201	4	1	SAFRAN	100000	58420	53109	91	45	38.09	22.9
2015-16	HUTNT	1201	4	2	SAFRAN	100000	63731	53109	83			
2015-16	HUTNT	1202	4	1	MERCEDES	400000	111529	79663	71	50	33.51	22.4
2015-16	HUTNT	1202	4	2	MERCEDES	400000	143394	79663	56			
2015-16	HUTNT	1203	4	1	DKW44-10	175000	106218	63731	60	50	34.2	13.8
2015-16	HUTNT	1203	4	2	DKW44-10	175000	74353	69042	93			
2015-16	HUTNT	1204	4	1	RILEY	250000	79663	63731	80	60	35.6	23.9
2015-16	HUTNT	1204	4	2	RILEY	250000	79663	53109	67			
2015-16	HUTNT	1205	4	1	SAFRAN	325000	111529	47798	43	45	41	27.1
2015-16	HUTNT	1205	4	2	SAFRAN	325000	106218	74353	70			
2015-16	HUTNT	1206	4	1	MERCEDES	325000	106218	53109	50	50	33.53	25.2
2015-16	HUTNT	1206	4	2	MERCEDES	325000	143394	58420	41			
2015-16	HUTNT	1207	4	1	RILEY	325000	79663	79663	100	50	36.91	23.3
2015-16	HUTNT	1207	4	2	RILEY	325000	79663	79663	100			
2015-16	HUTNT	1208	4	1	RILEY	400000	111529	74353	67	40	38.11	25.9
2015-16	HUTNT	1208	4	2	RILEY	400000	106218	53109	50			
2015-16	HUTNT	1209	4	1	SAFRAN	250000	100907	47798	47	40	33.23	23.1
2015-16	HUTNT	1209	4	2	SAFRAN	250000	95596	63731	67			
2015-16	HUTNT	1210	4	1	DKW44-10	325000	111529	58420	52	35	34.65	14.7
2015-16	HUTNT	1210	4	2	DKW44-10	325000	95596	63731	67			
2015-16	HUTNT	1211	4	1	MERCEDES	250000	100907	31865	32	35	39.6	17.5
2015-16	HUTNT	1211	4	2	MERCEDES	250000	100907	21244	21			
2015-16	HUTNT	1212	4	1	MERCEDES	175000	95596	58420	61	40	39.05	22.0
2015-16	HUTNT	1212	4	2	MERCEDES	175000	95596	69042	72			

2015-16	HUTNT	1213	4	1	RILEY	100000	79663	63731	80	40	38.41	23.1
2015-16	HUTNT	1213	4	2	RILEY	100000	74353	69042	93			
2015-16	HUTNT	1214	4	1	RILEY	175000	63731	58420	92	40	38.64	20.2
2015-16	HUTNT	1214	4	2	RILEY	175000	79663	42487	53			
2015-16	HUTNT	1215	4	1	SAFRAN	400000	95596	47798	50	45	42.75	38.0
2015-16	HUTNT	1215	4	2	SAFRAN	400000	111529	79663	71			
2015-16	HUTNT	1216	4	1	MERCEDES	100000	58420	42487	73	45	39.21	31.3
2015-16	HUTNT	1216	4	2	MERCEDES	100000	63731	47798	75			
2015-16	HUTNT	1217	4	1	DKW44-10	400000	100907	53109	53	45	38.9	24.2
2015-16	HUTNT	1217	4	2	DKW44-10	400000	95596	53109	56			
2015-16	HUTNT	1218	4	1	SAFRAN	175000	63731	31865	50	60	41.19	41.2
2015-16	HUTNT	1218	4	2	SAFRAN	175000	79663	42487	53			
2015-16	HUTNT	1219	4	1	DKW44-10	250000	53109	31865	60	50	38.35	27.4
2015-16	HUTNT	1219	4	2	DKW44-10	250000	95596	58420	61			
2015-16	HUTNT	1220	4	1	DKW44-10	100000	47798	42487	89	40	40.31	23.1
2015-16	HUTNT	1220	4	2	DKW44-10	100000	53109	47798	90			